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VOL. CXLV.—No. 3771] LONDON: FRIDAY EVENING, APRIL 20, 1928 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director-General, India Store Department, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—
SCHEDULE 1. 71,450 STEEL BOILER TUBES.
SCHEDULE 2. STERN WHEEL STEAMER.
SCHEDULE 3. HOSE PIPES and INDIA RUBBER FITTINGS for Vacuum Brakes.
SCHEDULE 4. 20 LOCOMOTIVE BOILERS, CYLINDERS, &c.
SCHEDULE 5. 4600 STEEL TYRES for Carriages and Wagons.
SCHEDULE 6. 3998 STEEL AXLES for Railway Carriages and Wagons.
SCHEDULE 7. 104 LOCOMOTIVE BOILERS, CYLINDERS &c.
SCHEDULE 8. 18 LOCOMOTIVES for Metre Gauge.
Tenders due on the 3rd May, 1928, for No. 1; on the 4th May, 1928, for No. 2; on the 8th May, 1928, for No. 3; on the 11th May, 1928, for Nos. 4 to 7; and on the 15th May, 1928, for No. 8.
Forms of Tender obtainable from the above at a fee (which will not be returned) of 5s. for each schedule. 8298

Assistant Engineer REQUIRED by the GOVERNMENT of TRINIDAD for the Public Works Department for 3 years' service, with possible extension. Salary £400, rising to £450 a year by annual increments of £25. Free passages. Candidates, 25 to 30 years of age, preferably unmarried, must be Corporate Members of the Institution of Civil Engineers or hold an Engineering Degree or Diploma recognised as granting exemption from Sections A and B of the A.M.I.C.E. examination. Must have had at least five years' practical experience on the construction of Public Works and possess a good knowledge, both theoretical and practical, of Waterworks Construction. —Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/620. 8283

Assistant Engineers REQUIRED for the PUBLIC WORKS DEPARTMENT of the FEDERATED MALAY STATES, for four years' service, after which, subject to satisfactory service, the officers appointed will be eligible for confirmation in the permanent and pensionable establishment. It is probable that the number of permanent appointments will be sufficient for those officers whose services have been entirely satisfactory, but no guarantee can be given. If at the end of four years' service an officer's services have been entirely satisfactory, and he is not offered or declines further employment, he will be paid a bonus of 2850 dollars. Salary, 400 dollars a month, rising to 800 dollars by annual increments of 25 dollars, plus a temporary non-pensionable allowance of 10 per cent. for bachelors and 20 per cent. for married men. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is considerably less than that of 2s. 4d. in the United Kingdom. No income tax at present imposed by the Federated Malay States Government. Free passages provided. Candidates, age 23 to 26, preferably unmarried, must have received a good theoretical training, preferably at a University or College recognised by the Institution of Civil Engineers, and possess a Civil Engineering Degree or obtain such other Diploma or Distinction in Engineering as the Secretary of State may decide in any particular case or have completed articles with a Civil Engineer of good standing, and have passed the examination for Associate Membership of the Institution of Civil Engineers. In addition, candidates must have had at least one year's practical experience of civil engineering under a qualified Civil Engineer.—Apply at once by letter, giving brief details of qualifications and experience, and stating age and whether married or single, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting clearly at the head of application M/15,224. 8224

Assistant Engineers (22) REQUIRED by the GOVERNMENT of NIGERIA for the PUBLIC WORKS DEPARTMENT, for two tours of not less than 12 nor more than 18 months' service in the first instance. Subject to satisfactory service, the officers appointed will be eligible at the expiration of three years' service for confirmation in the permanent and pensionable establishment. Salary £480 a year for the first three years, then £510, rising by annual increments to £920. Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates must have attained the age of 21½ years on the date of appointment, and should preferably have attained the age of 22½ and must not be over 35 years of age. Must have obtained an Engineering Degree at a recognised University or have passed Sections "A" and "B" of the A.M.I.C.E. examination or have passed the Associateship in Civil Engineering of the City and Guilds Institute, or possess such other Degree or Diploma or Distinction in Engineering as may be considered satisfactory. Candidates whose qualifying diplomas have been obtained without a college course should have had three years' practical experience of Civil Engineering under a qualified Civil Engineer. It is preferred that all candidates should have had two years' practical experience on good engineering work subsequent to taking their degree or completing their articles, but under certain conditions this may be waived in the case of candidates in possession of an Engineering Degree.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W. 1, quoting M/254. 8222

Draughtsman Required by the GOVERNMENT of NIGERIA for Railway Construction for a tour of 12 to 18 months' service, with possible extension. Salary £480 a year for the first three years of service and then rising to £720 a year by annual increments of £30. Free passages and free quarters. When permanent quarters are not available a commuted bush and travelling allowance of £9 a month is payable whilst engaged in the Colony upon construction work. Camp equipment provided. Outfit allowance of £60 on first appointment. Liberal leave on full salary. Candidates, age 25 to 40, should have had good experience in the preparation of drawings for works in connection with the Construction of Railways.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/465. 8255

The Engineer

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PUBLIC NOTICES

Assistant Land Officer and SURVEYOR REQUIRED by the GOVERNMENT of GAMBIA for two tours of not less than twelve nor more than eighteen months' service, with prospect of permanency. Salary £450 a year for the first three years of service, then £480, rising to £600 a year by annual increments of £30. Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, age 25 to 35, must be fully qualified Land Surveyors and have some knowledge of deeds relating to land and valuation of property, and some colonial experience of land surveying.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/423. 8254

Civil Engineers (2) REQUIRED by the GOVERNMENT of SIERRA LEONE for two tours of 12 to 18 months' service, with possible extension. Salary £600 a year, rising by annual increments of £30 to £720 a year. Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, aged 30 to 35, must have had experience in Road and Bridge Construction and Road Location Survey, and preferably be Corporate Members of the Institution of Civil Engineers or hold an Engineering Degree or Diploma recognised as granting exemption from Sections A and B of the A.M.I.C.E. examination.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/510. 8296

Department of Scientific AND INDUSTRIAL RESEARCH. A JUNIOR ASSISTANT (ENGINEER) is REQUIRED at the Building Research Station, Watford. Candidates must have a good Honours Degree or equivalent qualification and some research or practical experience.
Scale of salary £175-15-£235 plus Civil Service bonus; the bonus on £175 is at present at the rate of £90 19s. Provision for superannuation will be made under the Federated Superannuation System for Universities. Application forms to be obtained from the SECRETARY of the Department of Scientific and Industrial Research, 16, Old Queen-street, Westminster, S.W. 1, to whom they should be returned not later than April 30th. 8258

PUBLIC NOTICES

Administrative County of LONDON.
ROBERT BLAIR FELLOWSHIPS IN APPLIED SCIENCE AND TECHNOLOGY.
The London County Council invites APPLICATIONS for the AWARD of TWO ROBERT BLAIR FELLOWSHIPS in APPLIED SCIENCE and TECHNOLOGY, each of the value of £450, tenable for one year. The Fellowships are for advanced study or research in applied science and technology, and will be tenable in the Dominions, the United States or other foreign countries.
Candidates must be British subjects and at least twenty-one years of age.
Further particulars and application forms (T.2.a./300) may be obtained from the Education Officer (T.2.a.), The County Hall, S.E. 1 (stamped addressed envelope necessary), to whom the form must be returned by 18th June, 1928.
MONTAGU H. COX,
8245 Clerk of the London County Council.

Benares Hindu University.
ENGINEERING COLLEGE.
WANTED, a UNIVERSITY PROFESSOR of MECHANICAL ENGINEERING. Salary Rs. 1000 per month, rising by annual increments of Rs. 50 to Rs. 1500 per month.
Only University Graduates with Honours in Engineering and with at least 10 years' teaching experience and who are, at the same time, first-class practical men, need apply.
The gentleman appointed will have to sign an agreement to serve the University for at least five years.
The Engineering College is one of four at present existing on the University grounds, which occupy a pleasant site and cover an area of over 2 square miles.
The College was founded in April, 1919, and is now one of the largest Engineering Colleges in India. The workshop and laboratories are large and well equipped and further extension is now contemplated. The number of students at present in the College is about 450. The staff and students at present living on the site number over 2000, and the electric supply for all lights, fans and water is provided by the Engineering College.
Applications should reach the office of The Engineer, Box No. P4360, 33, Norfolk-street, Strand, London, W.C. 2, before May 1st, 1928.
The undersigned will be in England and interview selected candidates in May by special appointment.
CHARLES A. KING,
Principal, Engineering College, Benares Hindu University (India). P4360

PUBLIC NOTICES

University College of South WALES AND MONMOUTHSHIRE.
COLEG PRIFATHROFAOL DEHEUDIR CYMRU A MYNWY.
The Council of the College invites APPLICATIONS for the POST of PROFESSOR of ENGINEERING. Salary £1000 per annum.
Candidates should submit the names of three referees; they may also, if they so desire, send copies of testimonials. One hundred copies of applications and any testimonials submitted must be received, on or before April 28, 1928, by the undersigned, from whom further particulars may be obtained.
D. J. A. BROWN,
Registrar.
University College, Cardiff,
March 23, 1928. 8161

PATENTS AND DESIGNS ACTS, 1907 AND 1919.
Notice is Hereby Given that INVENTIA PATENT-VERWERTUNGS-GESELLSCHAFT, of Herrenacker 10, Schaffhausen, Switzerland, a body corporate, organised under the laws of Switzerland, SEEK LEAVE to AMEND the SPECIFICATION of LETTERS PATENT No. 263,148, granted to them for an invention entitled "Improvements in or relating to Dust Suction Apparatus."
Particulars of the proposed Amendment were set forth in the Illustrated Official Journal (Patents) of the 12th April, 1928.
Any person, or persons, may give Notice of Opposition to the Amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton-buildings, London, W.C. 2, within one calendar month from the date of the said Journal. 8277

"Earth Pressure Theories in RELATION TO ENGINEERING PRACTICE."
By LT.-Col. J. MITCHELL MONCRIEFF, C.B.E., M. Inst. C.E. (V.P.I. Struct. E.).
In response to numerous requests the Lecture on the above-named subject, delivered by Col. Moncrieff to the Institution of Structural Engineers on 23rd February, 1928, has been reprinted in booklet form (4to, 26 pp., 24 diagrams and illustrations) on art paper. Copies, price one shilling and twopence post free, may be obtained from the undersigned on application.
MAURICE G. KIDDY, F.I.S.A.,
Secretary of the Institution.
10, Upper Belgrave-street, London, S.W. 1. 8248

Abertillery and District WATER BOARD.
SALE OF PLANT.
The above Board offer FOR SALE extensive ELECTRICAL, STEAM and other PLANT recently used in the construction of a large concrete masonry dam.
The following are some of the principal items :—
Generating Plant, consisting of No. 2 Ruston and Hornsby 230 H.P. Gas Engines and Producer Plants with No. 2 Metropolitan Vickers 150 kW, 500 v. Dynamos.
No. 1 100 H.P. National Gas Engine and Producer Plant with No. 1 Bruce Peebles 100 kW, 500 v. Dynamo.
No. 4 Anderson-Grice 2-Ton, 3-Motor Electric Loco Cranes.
No. 4 Steam Derrick Cranes, 4 and 5 Ton.
No. 1 Ingersoll-Rand Air Compressor, 14in. by 12in., with 500-volt Motors.
No. 1 Double Concrete Hoist, 180ft. high, by Stothert and Pitt, with Trussed Steel Chutes, Hoisting Winches, 4-Yard Mixers, and 500-v. Motors.
No. 7 Steam Locomotives, 2ft. gauge.
No. 1 5-Ton Cableway, by Henderson, 1100ft. span; Luffing Head Masts, electrically driven.
50 Tons 56 lb. F.B. Rails with Fish-plates.
Further particulars can be obtained from the Board's Engineer, Mr. J. FRANCIS JUPP, M. Inst. C.E., Midland Bank Chambers, Newport, Mon. 8264

Bombay, Baroda and Central INDIA RAILWAY COMPANY.
The Directors are prepared to receive up to Noon on Friday, 4th May, TENDERS for the SUPPLY of :—
STEEL MATERIAL (Channels, Angles, Plates, &c.).
Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG,
Secretary.
Offices : The White Mansion,
01, Petty France, Westminster, S.W. 1.
18th April, 1928. 8282

Metropolitan Borough of St. PANCRAS.
BATHS DEPARTMENT.
The St. Pancras Borough Council invite TENDERS for the SUPPLY and ERECTION of ONE LANCASHIRE BOILER at the Whitfield-street Baths.
Plans can be seen and specification obtained at the offices of the Electricity Department, 57, Pratt-street, Camden Town, N.W. 1, on the payment of One Pound, which will be returned on the receipt of a bona fide Tender.
Tenders to be sent in on or before Noon on Friday, May 11th, 1928.
F. V. CREED,
Town Clerk.
Town Hall,
Pancras-road, N.W. 1. 8168

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PUBLIC NOTICES

South Indian Railway Company,
LIMITED.

The Directors are prepared to receive TENDERS for the SUPPLY of :—

1. STEEL WORK FOR BRIDGES.
2. PRESSED STEEL SLEEPERS.
3. LAMINATED SPRINGS.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Steel Work for Bridges," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, 4th May, 1928.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of the specification No. 1, of 10s. for each copy of the Specification No. 2, and of 5s. for each copy of the Specification No. 3.

Copies of the drawings may be obtained at the offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1,
20th April, 1928. 8281

State Electricity Commission
OF VICTORIA,
22-32, WILLIAM STREET, MELBOURNE, AUSTRALIA.

Separate TENDERS are hereby INVITED for the MANUFACTURE, SUPPLY and DELIVERY of SWITCHGEAR for the Yallourn Power Scheme, as follows :—

(A) SPECIFICATION No. 28/20.—120,000 V. Switchgear for Richmond Terminal Station.
(B) SPECIFICATION No. 28/21.—135,000 V. Switchgear for Yallourn Power Station Extension.

Copies of Tender form, specification, &c., will be available upon application to the Agent-General for Victoria, Victoria House, Strand, London.

Charge for specification in each case £1 1s. for three copies of Tender form, conditions of contract and specification complete, returnable under certain conditions as specified in the general conditions of tendering. Extra copies 10s. 6d. each, not returnable.

A preliminary deposit of £100 is to be lodged with Tender in each case.

Tenders, on prescribed form, properly endorsed and addressed, must be delivered at the office of the Commission, Melbourne, not later than 3rd September, 1928.

The Commission does not bind itself to accept the lowest or any Tender.

R. LIDDELOW,
8250 Secretary.

The Tralee and Fenit Pier and Harbour Commissioners invite TENDERS for the following :—

CONTRACT No. 1.—The SUPPLY and ERECTION of an OIL ENGINE and WATER PUMP at Fenit.

CONTRACT No. 2.—The SUPPLY and ERECTION of a LOCOMOTIVE STEAM CRANE at Fenit.

In accordance with the specification, copy of which can be had on application to the undersigned.

Sealed Tenders to reach me not later than 7th May, 1928.

The lowest or any Tender not necessarily accepted.

J. LAWLOR,
8246 Secretary.

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, REPRESENTATIVE for London District, used to Lancashire and similar type Boilers. Only those with technical and practical experience need apply.—Address, stating age, experience, and salary required, 8253, The Engineer Office. 8253 A

WANTED, Young ENGINEER, Conversant with Ironwork, especially Fencing, able to take over correspondence. Applicants must have knowledge of general business organisation. Good prospects.—Address, P4399, The Engineer Office. P4399 A

A WELL-KNOWN FIRM of Aircraft Engine Constructors REQUIRE the SERVICES of a BUYER, who should have technical as well as commercial knowledge. An energetic young man preferred, but must have experience.—Address, 8235, The Engineer Office. 8235 A

APPLICATIONS are INVITED for the POST of CHIEF WORKS ACCOUNTANT in Mechanical Engineering Factory, London district, employing approximately 1000 hands in the manufacture of specialised machinery, comprising over 6000 different parts. The Accountant appointed will be required to furnish reliable estimates of costs of manufacture of new parts and accurate costs of production of individual components (in all stages of manufacture and stock), assembled units and finished machines. Applications, which should include brief details of experience, age, salary, and any special qualifications for the post, will be regarded as confidential. Only fully qualified accountants already possessing similar experience need apply.—Address, 8203, The Engineer Office. 8203 A

COMPETENT WORKS MANAGER REQUIRED, Cheshire district. Must be good organiser with initiative and capable of handling labour for Structural Steel Work, mainly Buildings. State age, previous experience in detail, and salary required.—Address, P4417, The Engineer Office. P4417 A

EXCELLENT OPENING for ENGINEER With Commercial Experience and Knowledge of Water Softening. Steam raising experience also desirable. Applicants should give fullest details of past experience.—Address, P4432, The Engineer Office. P4432 A

REINFORCED CONCRETE SENIOR DESIGNER WANTED for Estimating Department. Must have had experience with specialist firms and be quick, accurate and competitive; only first-class men need apply.—Write, INDUSTRIAL CONSTRUCTIONS, Ltd., 44, Grosvenor-place, S.W. 1, stating briefly experience and giving age and salary required. 8244 A

WORKS ENGINEER, with 25 Years' Sound Shop and drawing-office experience, loco., steam, electrical, hydraulic, and rolling mill plant, W.T. boilers, construction, installation, maintenance of works, organisation and control of labour. Highest references.—Address, P4419, The Engineer Office. P4419 A

WANTED AT ONCE, LEADING DRAUGHTSMAN, with good experience, on Four-stroke Horizontal and Vertical Oil Engines. State age, experience, and salary required.—Address, 8241, The Engineer Office. 8241 A

WANTED by London Firm, a Smart Young CONSTRUCTIONAL DRAUGHTSMAN, able to design Steel Buildings, &c. State age, experience, and salary required.—Address, 8297, The Engineer Office. 8297 A

WANTED, First-class CHEMICAL and GAS PLANT DRAUGHTSMAN; must be capable with Plant Lay-outs and Process Work. State age and salary required.—Address, 8263, The Engineer Office. 8263 A

WANTED IMMEDIATELY in London, DRAUGHTSMAN with experience in Steam Power Station design, Pipe Work, and Structural Steel Lay-outs. Electrical knowledge desirable.—Reply, stating age, experience, salary expected, and when free, to Box No. 424, c/o Judd's, 47, Gresham-street, E.C. 2. 8278 A

WANTED in Midland District, MECHANICAL DRAUGHTSMAN. Some knowledge of Electric Lift and Hoist Work an advantage.—Address, giving details of experience, age, and wages required, 8247, The Engineer Office. 8247 A

A WELL-KNOWN North of England FIRM of Structural Engineers have a VACANCY for a fully qualified DETAILING DRAUGHTSMAN.—Address, stating age, experience, and salary required, 8293, The Engineer Office. 8293 A

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Parker Street, Kingsway, W.C. 2.

SITUATIONS OPEN (continued)

DETAILING DRAUGHTSMAN REQUIRED for Constructional Steel Works in North London. Must be able to prepare shop drawings with minimum supervision and be familiar with Steel Frame (1909 Act) Buildings.—Address, stating age, experience, and salary required, P4385, The Engineer Office. P4385 A

DRAUGHTSMAN, Capable Designer, Able to Work on own initiative, with experience in one or all of the following :—Rotary Air Compressors, Road Rollers, Commercial Vehicles ; £5 10s. to £6 per week, according to qualifications.—Address, 8266, The Engineer Office. 8266 A

DRAUGHTSMAN DESIGNER REQUIRED for London area. Must be thoroughly experienced in detail design of Mechanisms and Gearing Units. State age, salary required, experience, &c.—Address, 8280, The Engineer Office. 8280 A

DRAUGHTSMAN for Detail Work by London Engineers.—Write, stating experience, age, and salary required, to Box 8, c/o Mather and Crowther, Ltd., 10/13, New Bridge-street, E.C. 4. 8233 A

DRAUGHTSMAN REQUIRED, Experienced in Mechanical Detail Work Design on Compressors essential.—Address, stating age, experience, and salary required, 8260, The Engineer Office. 8260 A

DRAUGHTSMAN REQUIRED by Engineering Firm near Manchester, with knowledge of High-speed Steam Engines and Condensing Plant. Only applications from men with first-class experience will be considered. State salary required and when free.—Address, 8290, The Engineer Office. 8290 A

DRAUGHTSMAN REQUIRED for Constructional and General Engineering Work. Large works near Birmingham.—Address particulars of salary, experience, &c., 8295, The Engineer Office. 8295 A

DRAUGHTSMAN REQUIRED IMMEDIATELY, with good knowledge High-pressure Pipe Work Lay-outs ; some knowledge of Strains and Stresses desirable ; Birmingham district. State experience, age, salary required.—Address, 8249, The Engineer Office. 8249 A

DRAUGHTSMAN WANTED by Firm Near Manchester. First-class experience of Solid Injection Oil Engines essential and a knowledge of Air Compressors desirable. State age, experience, and salary required, and when free.—Address, 8289, The Engineer Office. 8289 A

DRAUGHTSMAN WANTED by Well-known Firm of Engineers specialising in Boiler-house Plants. Applicants must possess detailed intimate knowledge of Lay-out and Design of Combustion Equipment, Chain-grate Stokers, &c. State age, experience, salary required, when at liberty.—Address, 8287, The Engineer Office. 8287 A

DRAUGHTSMAN WANTED, One Experienced in Mechanical Engineering Design only ; no others need apply.—Address, giving full experience and salary required, 8261, The Engineer Office. 8261 A

DRAUGHTSMEN WANTED for London Works who have had experience with Printing Presses.—Address particulars of qualifications and salary required, 8251, The Engineer Office. 8251 A

EXPERIENCED DRAUGHTSMEN REQUIRED, with knowledge of General Engineering Work, Steel Structural Work or Chemical Plant Design and Lay-outs, for large factory in London.—Address, stating age, experience, and salary required, 8258, The Engineer Office. 8258 A

EXPERIENCED LADY TRACER REQUIRED.—Apply, CHIEF DRAUGHTSMAN, Barford and Perkins, Ltd., Peterborough. 8267 A

FIRST-CLASS DRAUGHTSMAN for London Office, capable of designing Steel-framed Buildings (L.C.C.), Bridges, Transmission Towers, and General Structural Steel Work. Minimum supervision. Only men with good technical and practical experience need apply. State age and salary required.—Address, 8237, The Engineer Office. 8237 A

JUNIOR DRAUGHTSMAN REQUIRED by a Firm of Constructional Engineers in London.—Address, stating age, experience, and salary required, P4384, The Engineer Office. P4384 A

JUNIOR DRAUGHTSMAN REQUIRED in London district ; must have had previous experience in the preparation of workshop details for Structural Steel Work.—Address, stating age, salary expected, and giving outline of qualifications, 8292, The Engineer Office. 8292 A

SENIOR LEADING DRAUGHTSMAN REQUIRED for works within 40 miles London. Applicants must be fully conversant with design of Asphalt and Tarmacadam Plants, Concrete Mixers, &c.—Address, stating age, salary required, and full particulars of experience, 8259, The Engineer Office. 8259 A

SEVERAL Young DRAUGHTSMEN REQUIRED, with knowledge of Railway Rolling Stock Construction for France. Would suit single men anxious to gain French experience. Salary offered equivalent £14 10s. per month, based on living conditions, which are cheaper in this part of France than in England. Address, with full particulars of experience, age, &c., P4415, The Engineer Office. P4415 A

STEEL WORK DESIGNER REQUIRED by Constructional Engineers in London. Competent to design for competitive work quickly and accurately. Give full particulars of experience, age, and salary required.—Address, 8291, The Engineer Office. 8291 A

STRUCTURAL DRAUGHTSMEN.—TWO JUNIORS REQUIRED for the City Office of London Constructional Engineers ; previous experience essential.—Please write, stating age, experience, and salary required, to "Z.G. 540," c/o Deacon's Advertising Agency, Fenchurch-avenue, E.C. 3. 8279 A

STRUCTURAL STEEL WORK DRAUGHTSMAN REQUIRED. Must be thoroughly experienced in London work and competent to design and carry out contracts for Steel-framed Buildings. State salary and experience.—Address, P4414, The Engineer Office. P4414 A

TWO First-class DRAUGHTSMEN REQUIRED IMMEDIATELY. Experience in design of Woodworking Machinery essential.—Apply, A. RANSOME and CO., Ltd., Stanley Works, Newark-on-Trent. 8288 A

FOREMAN BLACKSMITH REQUIRED, to Take Full Charge of Railway Works Smithy, Spring Shop and Forge. Must be thoroughly practical man, accustomed to all classes of Railway Work.—Address, stating age, experience, &c., 8234, The Engineer Office. 8234 A

LARGE and Old-established FIRM of Constructional Engineers in India REQUIRE a STEEL STRUCTURAL FOREMAN, age under 25, unmarried.—Reply, giving fullest details, education, experience, present work, and salary, to Z.W. 551, care of Deacon's Advertising Agency, Fenchurch-avenue, E.C.3. 8284 A

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For continuation of Small Advertisements see page 4.

A Seven-Day Journal

The Central Scotland Transmission System.

In consequence of the difficulties encountered in carrying out the original plan in connection with the overhead transmission system of the Central Scotland Electricity scheme the route has been altered. The original proposal to carry the line across the Forth Bridge has been opposed by the railway company, and the scheme has been abandoned. A new route has been decided upon, which will involve a crossing about 15 miles higher up the river. The line was originally planned to run from Portobello, skirting Edinburgh, to the south to a point near Ratho, thence striking almost due north to the Forth Bridge and joining the northern line to Kirkcaldy and Dundee at Dunfermline. In accordance with the modified scheme, however, the line will be carried westwards beyond Ratho to a point near Mid-Calder, whence it will strike in a north-westerly direction and join the northern line at Bonnybridge. A minor alteration has also been made on the original line of route between Bonnybridge and Dunfermline. The line to the north was to have been carried across the Forth near Alloa, but a slightly shorter route has been adopted by selecting a point near Culross for the crossing of the river. Thence it will run almost due west to Kirkcaldy, and from there, following the modified plan for the Tay crossing, it will run northwards to a point near the junction of the Earn and the Tay and along the Carse of Gowrie to Dundee. The change of route will carry the line through an important new area, and will render a supply of electricity available in the event of further industrial development in West Lothian. With the modifications now adopted three river crossings of a major character are involved. One over the Clyde at Yoker, one over the Forth, and one over the Tay. In each case the span will be in the neighbourhood of 1700ft., and in order to allow the minimum clearance of 120ft., the lines will be strung from steel towers of from 250ft. to 300ft. high, on the banks of the rivers.

Rates and Industry.

The Engineering Employers' Federation has issued a memorandum to its constituent firms on the burdens imposed on industry by local taxation. The memorandum describes these burdens as becoming intolerable, and states that the sum expended on local taxation, social services and unemployment contributions is three times as great as it was in 1913. It estimates that one-fourth of the total local rates in Great Britain is contributed by industry. In 1914 these rates amounted to £79,000,000. By 1926 they had risen to £166,000,000. In 1913 local rates, workmen's compensation and national insurance represented an impost of 4s. 1d. on the cost of producing a ton of steel. In 1923 the corresponding figure was 11s. 1d. per ton. To-day the memorandum estimates that the total load of rates and social service charges amounts to at least 9 or 10 per cent. of the selling price of raw or semi-manufactured materials. Dealing with the burden on industry represented by one and a-quarter million unemployed, the memorandum urges that a more exact analysis of the total should be made than that so far attempted. The Ministry of Labour's "sample analysis," to which we referred in a "Journal" note in last week's issue, is described as neither satisfactory nor conclusive.

The National Physical Laboratory.

The annual report of the National Physical Laboratory reveals in a striking manner the extraordinary extent to which this department of the State's activities has grown since it was founded in a humble way a quarter of a century or so ago. The compilers of the report make no attempt at comparison with a view to presenting a general picture of the Laboratory's growth, but only a short study of it is required to obtain a good impression of what it has been. Of the tests conducted for payment on behalf of outside bodies or firms, the report records a material increase, an increase which in some departments has reduced the time available for fundamental Laboratory research. Some idea of the magnitude of this section of the Laboratory's work may be gained from the fact that during the year over 536,000 clinical and nearly 7000 other thermometers were tested, while taximeters and taximeter gear-boxes tested numbered 28,766. In the Optical Department over 3000 tests were conducted on sextants, telescopes, prisms, lenses, &c. In the Metrology Department over 12,000 tests were made on ruled scales, gauges, weights and measures, leading screws, chronometers and other measuring devices. In the Engineering Department 1445 tests were carried out on the strength of materials, lubricants, brake linings, road materials, standard reference jets, and so forth. At the National Tank, seventy-one tests were made on ship and similar models. Great as is the amount of work indicated by these figures, outside paid work forms the less absorbing part of the Laboratory's activities. Of the fundamental research work conducted, it is quite impossible to present an adequate summary in a brief note. It may perhaps be a sufficient indication if we say that the staff numbers 562, of whom 261 occupy positions demanding scientific or technical qualifications, the remainder, 301, being below the rank of junior observer.

The New Orient Liner Orford.

The directors and managers of the Orient Line entertained a large number of guests over the Easter week-end in their new geared turbine twin-screw steamer "Orford," of 20,000 gross tons. Leaving Tilbury on Thursday afternoon and anchoring at the Nore for the night, she reached Antwerp early on Friday afternoon, where she remained until 2 p.m. on Sunday afternoon. After clearing the mouth of the Scheldt, the "Orford" proceeded down Channel, round the Wight and as far westward as Torbay, where she turned. Coming up Channel, she anchored off Cowes for the night and reached Southampton early on Tuesday morning. The "Orford," a sister ship of the "Orama," "Oronsay," and "Otranto," is as perfect as her designers, builders and decorators can make her. Steaming at 20 knots, vibration is practically unnoticeable, and rigidity is most marked. A new departure from the design of her sister ships is that the staircase leading to the boat deck enters that deck amidship, and facing aft, instead of the two stairways opening to port and starboard. This improvement has undoubtedly added to her rigidity. Perfect weather, the kindest of hosts and a fine ship rendered the cruise a most enjoyable one, and one to be remembered.

Harland and Wolff, Ltd.

In the annual report of Harland and Wolff, Ltd., of Belfast, it is stated that after paying a dividend of 6 per cent. on the first preference shares and making a transfer from the reserve account, a credit balance of £95,203 on the profit and loss account has been carried forward. The reserve account, which a year ago stood at £1,300,000, is now stated to amount to one million pounds. Reference was made in last year's report to the continued partial suspension of operations at the shipyards owing to the shortage of material consequent upon industrial troubles. This cause, together with the fact that certain work was taken on at unremunerative prices in order that the regular workmen might be kept more fully employed during the period of depression, it is stated, materially affected the results of the past year. The work at present in hand should, however, warrant a very substantial improvement in the year 1928. Some interesting figures are given in the report showing the combined outputs of gross tonnage and indicated horse-power from the Belfast, Glasgow, and Greenock establishments of the firm over the five years up to December 31st last. These figures are exclusive of the output from the yards of associated companies and are as follows, the first figure after the year being the total gross tonnage, and the second the total output of machinery in indicated horse-power:—1927, 94,700, 80,575; 1926, 88,333, 73,470; 1925, 113,300, 88,540; 1924, 105,389, 88,400; 1923, 102,006, 71,450. Last year marked the twenty-first occasion upon which the company had attained the first place in the annual tonnage returns of British shipbuilders.

The Longest Non-stop Railway Run.

On Wednesday last, April 11th, an inspection took place at the King's Cross suburban station of two of the new L.N.E.R. locomotives which will be used to draw the London to Edinburgh non-stop "Flying Scotsman" expresses. The first trip is to be made on May 1st, and the 392-mile run is reported to be the longest non-stop run in the world. The outstanding feature of the engine is the provision of a corridor through the tender, whereby a relief engine crew will be able to gain access to the footplate from the guard's van. By a slight rearrangement of the coal space it has been found possible to construct a corridor passage 1½ft. wide and 5ft. high. The first crew will work the train up to a point a little north of York, at which the men will be relieved by a second driver and fireman, who will travel as passengers for the first 200 miles.

Takoradi Harbour.

Last week the recently completed deep water harbour at Takoradi on the Gold Coast was formally opened by the Rt. Hon. J. H. Thomas. The work was begun in 1923, and has been carried out by Sir Robert McAlpine and Sons, to the designs of the consulting engineers, Messrs. Rendel, Palmer and Tritton, of Westminster. Two breakwaters have been constructed, which enclose an area of water of close upon 220 acres. The main or southern breakwater is designed to overlie the lee arm by about 500ft., so that a fairway is created. At the harbour entrance there is a width of 600ft. The main breakwater has a length of close upon 1¼ miles, and for about three-quarters of a mile it has been built along the northern edge of a natural sandstone reef. From this point it curves in a northerly direction into water averaging 42ft. in depth. The width at the top of the main breakwater is 30ft., and at its heaviest section it is 60ft. high with a base of 250ft. The lee breakwater is about one mile in length, and stands 10ft. above low water level, the width at the top being 15ft. On the inner side of the lee breakwater there is accommodation for three ocean-going steamships at one time, and the depth of water varies from 25ft. to 33ft. Main transit sheds have been erected, and facilities for loading manganese ore will be provided. On the west lighter wharf, which is 2159ft. long, provision is made for the storage and shipment of cocoa and timber. A small slipway forms part of the harbour equipment, which includes a full complement of lifting appliances. There are six sets of mooring berths for ocean-going vessels, arranged within the harbour, as well as lighter moorings. Within the harbour area a very complete system of railways and motor roads has been provided, with connections to all the buildings.

Workman Clark (1928), Ltd.

In a Journal Note in our issue of March 9th we referred to the company which was then being formed to take over the business of Workman, Clark and Co., Ltd., of Belfast. That company has now been incorporated under the style of Workman, Clark (1928), Ltd., and it will enter into possession of the yards and works from the joint receiver some time during the present month. Its nominal capital is £400,000 in £1 shares, and the first directors are Mr. William Strachan, a director and secretary of the old company, Mr. James Wilkie, the general manager of the engineering department of the late firm, and Mr. William James Lovett, who was with the firm for many years as its naval architect. The other two directors are Mr. John Wylie Hamilton, formerly a director of William Hamilton and Co., shipbuilders, of Port Glasgow, and Mr. Patrick Campbell Anderson. The secretary of the new company is Mr. F. Cunningham, who was for many years the secretary of the old firm's engine works department. The company is a private concern, and it has been registered at the Ministry of Commerce of Northern Ireland. The floatation is said to be the largest which has taken place in connection with any company in Ireland since the Ministry of Commerce was established. There are reasonable prospects, it is understood, of operations being begun at the yards before very long.

Waterways or Motorways.

Considerable interest is being shown in the rival schemes of transport now being pressed upon Birmingham and Midland manufacturers. For a considerable time it has been realised that unless transport costs are reduced many of the works which are now situated in the Midlands will be unable to compete with those situated near the ports, and that there will be a further removal of works from the Midlands to the coast. The means suggested for combating this possibility are a motorway and the existing waterways. Much has been written about the possibilities of the development of inland waterways, on behalf of which it is argued that from an economic point of view there is nothing to surpass transit by water. If, it is urged, the waterways can be developed to take barges large enough to navigate the estuaries, goods could be shipped direct into or from ocean-going vessels. The newer proposal is to construct a £6,000,000 motorway between Birmingham and the Mersey, linking up the important towns on the way, and thus facilitating the transport of goods manufactured in the Midlands from factory to coast. The promoters of the motorway scheme claim that it would offer a quicker and cheaper means of transit than is available at present. They state that it would be possible to make the double journey by road in at least half the time taken for the single journey under present conditions. In the construction of the road care, it is emphasised, would be taken to eliminate serious gradients and bends in order to reduce running costs and to facilitate the attainment of high speed.

A Rail Disaster in France.

It is with regret that we have to place on record a serious railway collision which took place about half a mile from the Gare du Nord, Paris, at 1.20 p.m. on Wednesday, April 11th. The accident was attended with the loss of life of sixteen people, while twenty-five persons were injured. It is reported that a suburban train from Villiers le Bel and Pierrefitte, which was scheduled to arrive at the Gare du Nord at 1.12, collided head-on with a crowded passenger train for Amiens, which had left Paris at 1.15. The accident took place on the station side of the Doudeauville Bridge. The two engines were raised on end by the force of the impact and many coaches were telescoped. The train to Amiens, which was not travelling so fast as the local train, sustained the most damage. According to reports, it is understood that the accident was caused by the failure of the driver of the Paris–Amiens train to notice a number of signals which were against him.

Calcutta Waterworks.

No. I.

The city of Calcutta has a filtered and an unfiltered water supply, both being taken from the river Hooghly. In 1870 about three million gallons of filtered water per day were supplied to the city. From time to time the works were altered and enlarged, and in 1920 a supply totalling about 37½ million gallons per day was being afforded, full pressure being maintained for four hours only in the morning and three hours in the afternoon. After filtration at the intake works the water was conveyed partly by pumping and partly by gravitation to an underground reservoir at Tallah, on the northern outskirts of the city, where it was again pumped and distributed over the city, a large steel reservoir raised over 100ft. above the ground, and containing nine million gallons, being provided to form a reserve during the hours of minimum demand for use during the hours of maximum demand. From Tallah it was conveyed to the city through one steel main commencing at 72in. diameter and diminishing to 60in. about half a mile from the pumping station, and two 30in. mains. The 60in. steel main terminated at a point about 3¼ miles from Tallah approximately in the centre of the city, and, as a consequence, the northern portion of the area got more than its share of the available and inadequate supply at the expense of the southern portion.

In 1878 about one million gallons of unfiltered water per day were supplied to the city. By 1920 the supply had been increased to about 29 million gallons per day, but both as regards quantity and pressure it was insufficient.

In 1920 the position had become so serious that the Corporation called in the late Mr. St. George Moore of Messrs. St. George Moore and La Trobe Bateman, of Westminster, to report on the whole position and to suggest measures for its improvement. His report recommended the abolition of the unfiltered supply and the provision of a continuous supply of 100 million gallons of filtered water per day for the city and its suburbs, that amount representing about 80 gallons per head on the estimated population in 1941. In 1921, however, the Corporation resolved to continue and enlarge the unfiltered supply and to increase the filtered supply to 70 million gallons, 65 million gallons being for the population within the city boundaries and 5 million gallons for adjacent municipalities. Messrs. Moore and Bateman were appointed to act as consulting engineers and instructed to proceed with the design of the works necessary to comply with the decision arrived at.

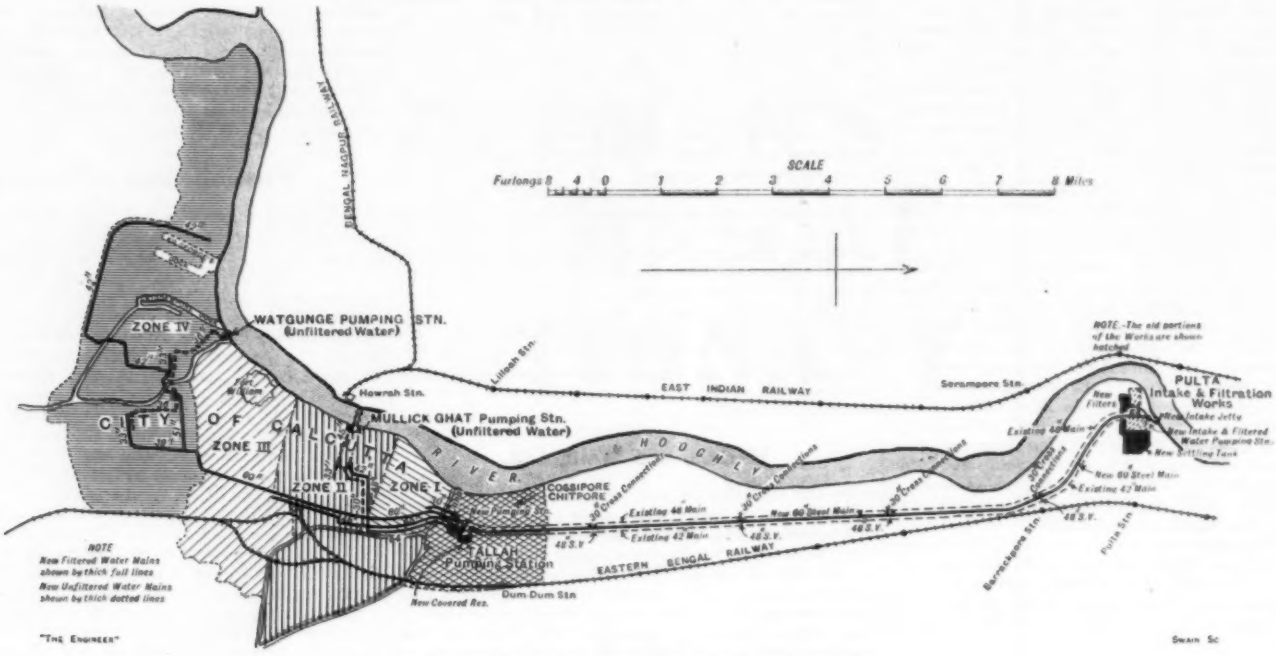


FIG. 1—PLAN OF CALCUTTA WATERWORKS SYSTEM

Filtered Supply.

Sixty-five million gallons of filtered water daily are equivalent to an average allowance of 62·1 gallons per head per day on a population in the city of 1,047,000, which figure, it was estimated, would be reached in 1941. In 1923, however, the city boundaries were extended to take in three of the out side municipalities, and the extension increased the estimated total population in 1941 to 1,322,000. At 62·1 gallons per head this represents a daily supply of 82,096,000 gallons. Adding to that volume the water which had to be provided for sale to outside municipalities on the fringe of the city, the daily requirements for which provision had to be made became 83,554,000 gallons. Taking into account the quantity of water required for sand washing and the loss due to evaporation, the total quantity of water which has to be taken daily from the river is estimated at 88,854,000 gallons. Several contracts had already been let and commenced before 1923, and they had to be modified, and the works had to be extended to suit the greater volume required. The works existing in 1921 had furnished a daily supply of about 38,000,000 gallons of filtered water, and hence the new works as modified had to provide for an additional volume for distribution of 45,500,000 gallons per day.

Fig. 1 gives a general plan of the whole scheme as it is now being carried out, and from it it will be seen that the intake and purification works for the filtered supply are situated at Pulta, which is about 12 miles upstream from the northern boundary of the city. From Pulta the water is pumped to Tallah, where it is again pumped and distributed throughout the city. The city, under the new scheme, has been divided into zones, each with its own independent arterial main from the pumping station at Tallah. These mains have been laid out so that the terminal head in the distribution piping shall not be less than 40ft. at any part of a zone. Each arterial main is

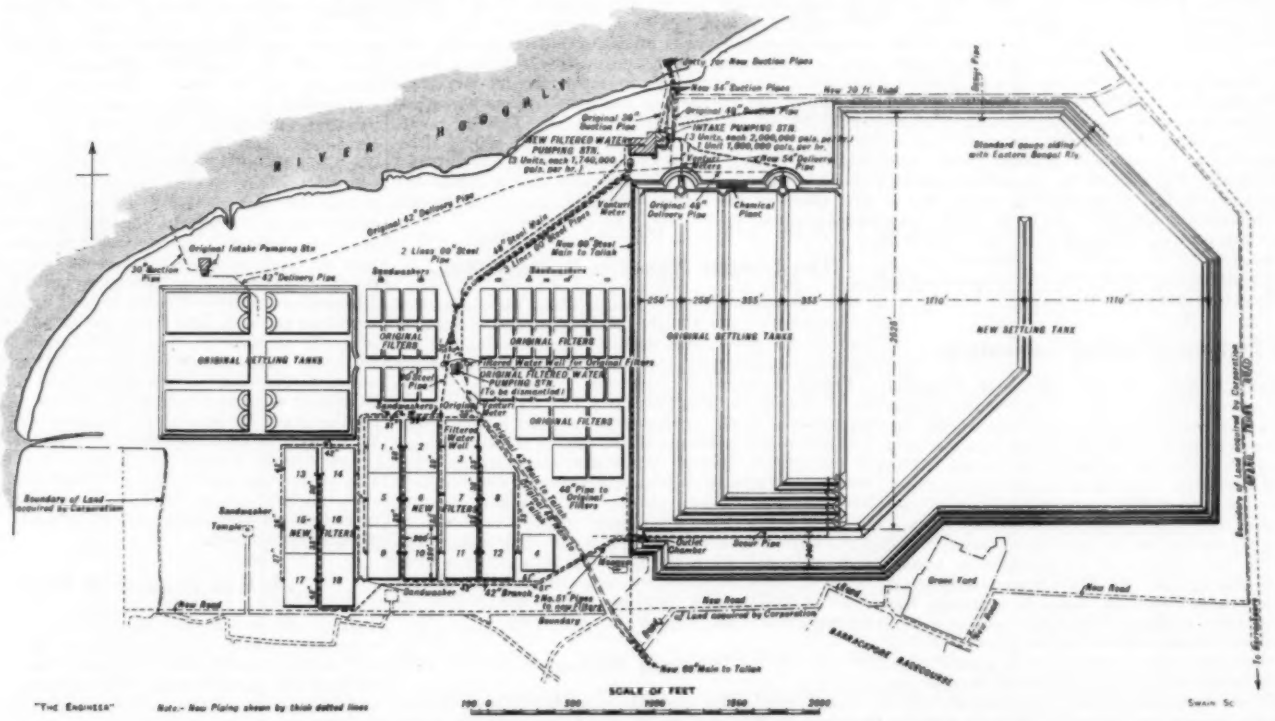


FIG. 2—GENERAL PLAN OF INTAKE AND FILTRATION WORKS AT PULTA

provided with a Venturi meter at Tallah, thus enabling complete control to be kept of the quantity of water supplied to each zone.

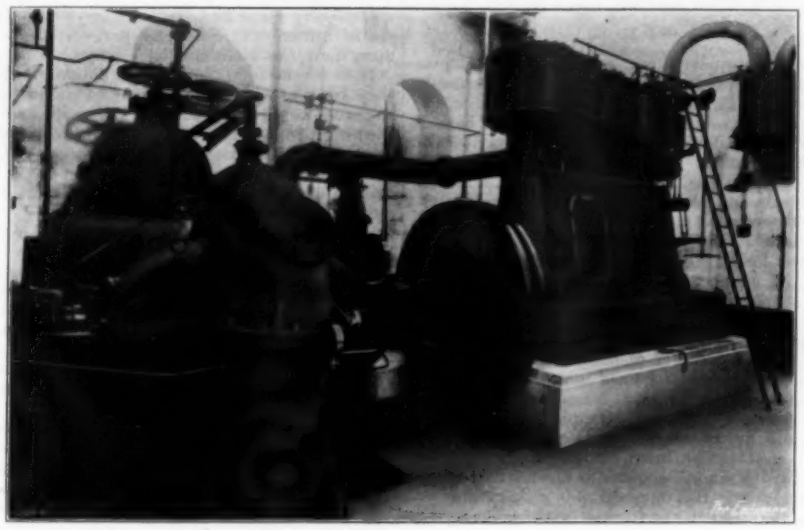


FIG. 3—NEW PUMP AT PULTA INTAKE STATION

Fig. 2 gives a general plan of the new and existing works at Pulta. In 1921 the plant at the main intake pumping station consisted of one Worthington-Simpson centrifugal pump, capacity 2,000,000 gallons per hour, coupled to a Belliss and Morcom high-speed triple-expansion engine, and three Fawcett and Preston vertical compound engines and plunger pumps, erected in 1887, original capacity of each set 650,000 gallons per hour. The plant, with the exception of the centrifugal pump, was worn out and incapable of doing the work required. About half-a-mile downstream there is another intake station with two Worthington-Simpson triple-expansion vertical engines and plunger pumps, with a total pumping capacity of about 12 million gallons per day. At times of high spring tides there is a tendency, during a few days, for the river water to be brackish for eight hours out of the twenty-four, and the pumping capacity has therefore to be sufficient to pump all the water required in sixteen hours.

The total quantity required under the new scheme, including that for sand washing and losses by evaporation, amounts, as stated above, to 88,854,000 gallons daily, or 5,553,000 gallons per hour when pumping for sixteen hours.

The old Fawcett and Preston engines and pumps have been scrapped and the plant for obtaining the required quantity and providing for spare power will consist of four units, viz., (*a*) the existing Worthington centrifugal unit—capacity 2 million gallons per hour—(*b*) one new similar unit of the same capacity, which is already erected and is seen in Fig. 3; and (*c*) two units which are to be moved from the existing filtered water pumping station when the latter station is dismantled and the new filtered water station—to be described hereafter—is brought into use. These two units have centrifugal pumps coupled to triple-expansion vertical high-speed engines, their capacities being respectively 2,000,000 and 1,600,000 gallons per hour. The total capacity of the station when all the units are erected will therefore be 7,600,000 gallons per hour. The basement of the existing building is being used to house the plant.

The boiler plant in use in 1921 consisted of four old Lancashire boilers, which will be scrapped, and three Babcock and Wilcox boilers, which will be retained. Further boiler power will be provided by installing two Babcock and Wilcox boilers, which are to be moved from the existing filtered water pumping station, and by a new boiler of similar type which has been erected.

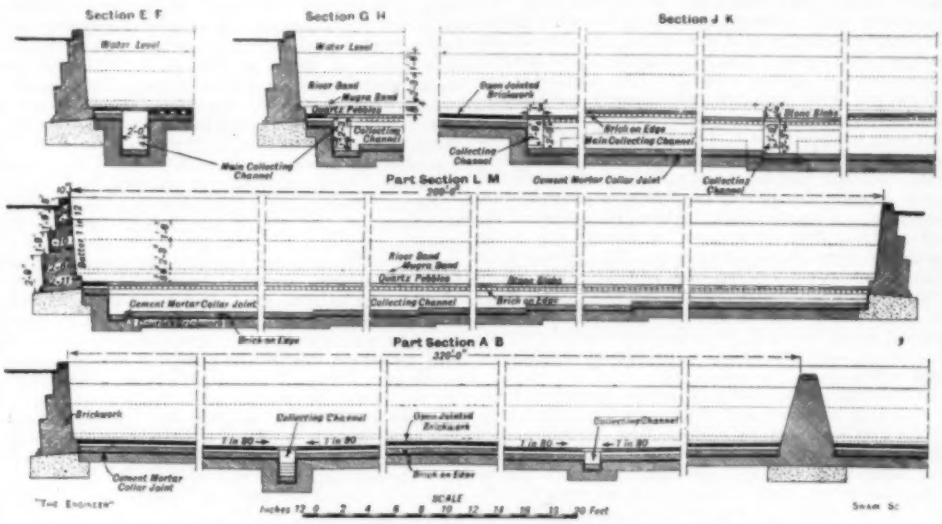


FIG. 5—SECTIONS OF FILTERS ON LINES SHOWN IN FIG. 4

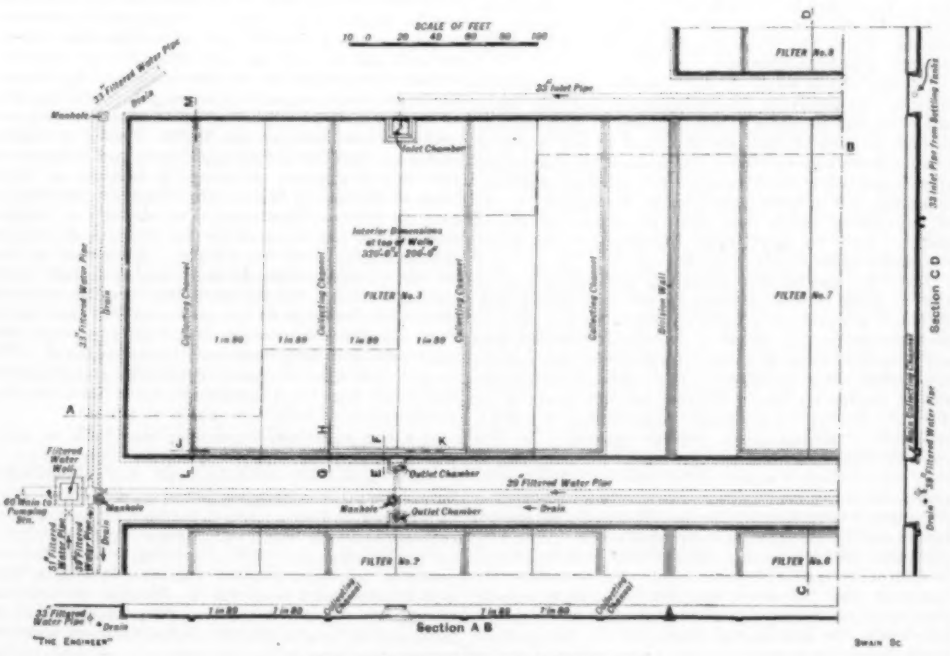


FIG. 4—ARRANGEMENT OF FILTERS

In addition to the existing 36in. and 48in. suction pipes, three new suction pipes, 54in. diameter, have been provided, one for each of the new units. At the river end, these pipes are supported by a steel screw pile jetty, their ends being encased in steel grids, and the new jetty being tied into the jetty carrying the existing 36in. suction pipe. Each pump delivers through a 48in. cast iron pipe into a steel chamber, 78in. diameter. The outlet end of this chamber is bifurcated to form two 48in. branches on which are fixed 48in. sluice valves, the diameter of the two pipes immediately beyond the sluice valves being increased to 54in. Each pipe is provided with a Venturi meter, and terminates in a new stilling chamber from which the water flows over a weir into the existing stilling chambers and thence along channels, commanded by penstocks, extending the whole width of the existing settling tanks. From these channels the water, after being chemically treated as and when required, spills over into the four existing settling tanks.

The capacity of the settling tanks has been increased by 187 million gallons, which, together with the contents of the existing tanks, is sufficient to furnish three days' supply. The existing tanks are at present worked in series, but under the new scheme they are being altered to act in parallel as pre-sedimentation tanks, each tank being provided with its own outlet to the new tank, so that any tank can be put out of action for cleaning or repairs without interfering with the supply. The new tank covers an area of about 130 acres, and is formed by banking up the land immediately to the east of the existing tanks. The material for the banks was obtained partly from the excavation for the new filters and partly from material excavated within the site of the tank. The banks have a core of selected material, carried well below the existing ground level, obtained from the deposit cleaned out of the existing settling tanks. A central bank divides the tank into two parts, so that the water has to travel twice the length of the tank. The inner slopes of the banks are pitched with brick on edge laid over two bricks flat in lime mortar, the pitching extending from 4ft. 6in. below the lowest draw-off level to 5ft. beyond the edge of the top of the side banks and completely covering the top of the central bank.

From the outlet chamber, which is situated at the extreme south-west corner of the new tank, two 51in. pipes convey the water to the new filters and one 48in. pipe connects up with the pipe leading to the existing filters. The general lay-out of the intake works and settling tanks is shown in Fig. 2. There is a large amount of suspended matter in the raw water and the question as to the best method of dealing with it, which is a problem of great importance, is still under consideration.

Eighteen new filters are provided. Seventeen of them have each a capacity of 3 million gallons per day, and one of them a capacity of 2 million gallons, the rate of filtration being in all cases 2 gallons per square foot per hour. The filters are arranged in two groups, one containing twelve beds and the other, which was added after the city boundaries were extended in 1923, containing six beds. Each group has its own supply pipe from the settling tanks. Both pipes are 51in. diameter where they leave the settling tanks and are reduced in size as the branches between the lines of filters are taken off them, a 42in. branch being provided for future extension on the 51in. pipe leading to the western group. The branch pipes between the filters are also reduced in diameter as the supplies to the various beds are connected to them—see Fig. 2.

The filter walls are formed of brickwork on a foundation of lime concrete, the floor being formed of three courses of brickwork laid flat and one course of brick on edge with a cement mortar collar joint between them. On top of the floor is laid a false floor for leading the filtered water to the collecting channels. It is formed of two courses of dry brickwork, the lower

course being spaced half a brick wide and the upper course laid across the lower with a spacing of about ½in. Each filter is provided with four collecting channels, which discharge into a main collecting channel leading to the outlet chamber, the floor falling towards the collecting channels at a gradient of 1 in 80. The filtering medium is composed of 2ft. 3in. of river sand, 4in. of coarser Mugra sand, and an average depth of 5in. of quartz pebbles.

The branches to the inlet chamber, which are of cast iron 15in. diameter, terminate in a vertical bell-mouthed pipe in the inlet chamber, from which the water flows on to the beds over a weir formed of a marble slab. The outlet chambers are lined on the inside with white glazed bricks. Cast iron pipes, 15in. diameter, connect them with the system of piping leading to the filtered water well. Drains are provided connecting the beds with a main drain leading to the river Hooghly. The arrangement and details of the filters are shown in Figs. 4 and 5.

The water from each group of filters is conveyed by pipes varying from 24in. to 51in. diameter to a filtered water well, from which it gravitates to a well at the commencement of the suction culvert for the pumping station, a distance of about 2000ft. This length is divided into three sections by two chambers, the water being conveyed from the well to the first chamber by one 60in. steel pipe. At the first chamber the water from the existing groups of filters is picked up, that from the eastern group by a 51in. pipe and that from the western by a 36in. pipe. Between the first and second chambers there are two lines of 60in. steel pipes and from the second to the suction well three lines of 60in. steel pipes. The 60in. pipes where they enter and leave the chambers are provided with 48in. sluice valves and inspection branches.

As already mentioned, the existing filtered water pumping station will be dismantled and a new pumping station erected to deal with the whole supply. For convenience and economy in working the new station has been built alongside and is joined up to the intake station. The quantity to be delivered is 83,554,000 gallons per day against a head of 120ft., or 3,481,400 gallons per hour pumping continuously for twenty-four hours. For this purpose three pumping units, each with a capacity of 1,740,000 gallons per hour, are provided. Each unit consists of a 30in. Mather and Platt hydraulically-balanced split-casing centrifugal pump, coupled through double helical single-reduction gearing to a Parsons steam turbine, the speed of the turbine being 6000 revolutions per minute and of the pump 550 revolutions per minute. The pumps draw from a suction culvert 8ft. high and 9ft. wide, which extends the whole length of the engine-house. Each set is provided with a surface condenser, the condensing water being drawn from the suction culvert, to which it is returned after it has passed through the condensers.

To furnish the necessary steam for operating these units, three Babcock and Wilcox boilers, fitted with mechanical chain-grate stokers and Diamond soot blowers, have been provided. Each has an evaporative capacity of 18,000 lb. per hour and each has its own economiser, steel chimney and induced draught fan. A coal breaker, a coal conveyor, and bunkers are installed, from which the coal is delivered by chutes into the stoker hoppers. Steam is supplied at a pressure of 200 lb. per square inch at the stop valve, superheated to a temperature of 550 deg. Fah.

Three 100-kW generating sets, driven by Parsons turbines of a special design, supply power for the auxiliary machinery and for lighting purposes. The speed of the turbines is 10,000 revolutions per minute and of the generators 3000 revolutions per minute. Steam is supplied from the boilers for the main pumps, two surface condensers being provided.

The pumps and generating sets are under one roof, one overhead travelling crane serving for both. A view of the south elevation of the station is shown in Fig. 6, page 406. The turbine and pump-house is on the extreme left, the coal conveyor and bunkers being situated between the boilers for the turbines and the additional boilers for the intake pumps. On the extreme right is the existing house, the basement of which has been used for the new intake pumps. An engraving reproduced from a photograph of the main turbines and pumps with the 100-kW generating sets in the foreground is seen in Fig. 7. A siding from the Eastern Bengal Railway will convey material to the works, and the whole area is provided with a system of light railway tracks.

(To be continued.)

An Order in Council, published in the *London Gazette*, prohibits the sale of explosives other than gunpowder except under a certificate given by a chief officer of police. The Order applies to all explosives other than gunpowder, small-arm nitro compound, safety cartridges made with gunpowder, or with small-arm nitro compound, cartridges or charges of cannon or blasting made with gunpowder and not containing within themselves their own means of ignition, percussion caps, safety fuse, or fireworks. No person shall sell any explosive to which the Order applies unless he satisfies himself that the person desiring to buy the explosive possesses a police certificate issued in accordance with the Order made in 1883. The Order does not apply to the owner, agent or manager of a mine or quarry in respect of the sale by him of explosives to his employees for immediate use in a mine or quarry. The Order is cited as the Sales of Explosives Order, 1928.

General Development of the Locomotive.

(By a Continental Engineer).

No. I.

The steam locomotive is a prime mover, independent of any central source of energy; it has always answered to the increasing demand of the traffic, and its study has never been as interesting as it is now, in view of the striking and steady progress made in the last fifteen years.

The locomotive is subjected to two principal laws: increase of size and power; decrease of specialisation. The first statement is so obvious that it does not need any comment. The limits are principally the dimensions of the loading gauge and the weight, total or per axle, of which the latter has some elasticity, since the strength of the permanent way or bridges can be increased.

The truth of the second statement is less evident *a priori*. As the number of coupled axles increases, express engines become better adapted for pulling heavy and slower trains, or at least fast goods, while formerly a single type, for example, was especially designed for light and fast express trains. It is frequent, on the Continent or in America, to see "Pacific" or "Mikado" engines at the head of freight trains, particularly fish or perishable goods trains.

The engines built in the twenty or thirty last years of the last century, and notably the single large driving wheel locomotives, were able to attain, with sufficiently light loads, higher speeds than were practically necessary, or suitable for the profile of the lines, the radii of the curves, and the equipment of the permanent way. On a perfect road, not including sharp curves, single engines, such as those used for many years by the old Great Northern or the Midland, of which the stability was excellent, running light, had no other real limit to a greater speed than the rate asked of them or the cross section of their steam ports which could have been made larger if it had been considered desirable. There is not an engine built now that could beat them in this respect. Were not, at the time of the race to Edinburgh, the Ramsbottom's engines of 1859 selected to run the trains, and they were only six-wheelers?

The maximum speed obtainable is also a function, of course, of the weight per horse-power. A locomotive weighing, for example, 75 lb. per H.P. will be able, all things being equal, to attain speeds greater than an engine having a corresponding weight of 130 lb., and so forth. One sees immediately the necessity of a strong draught and a high rate of combustion for obtaining high speeds. The use of low-grade fuel and moderate draught is contrary to the principle of the locomotive. But there is a limit; the efficiency of the boiler decreasing with the intensity of the draught and, after a certain point, the production of steam is not in proportion with the fuel burned. Going further, a point would be reached beyond which this production would not increase at all—but even decrease—whatever were the weight of coal burned per square foot of grate and per unit of time. To avoid that limit, all increase of power requires a proportional increase of grate area and of heating surfaces.

It is not, therefore, as every one knows, in the direction of greater speeds, properly speaking, that one must look for the improvements of the steam locomotive which have been made within the past thirty years and more especially within a much later date. There is nothing new in this statement to the specialists, but it is apt to be overlooked by those outside of railway circles.

In one word, even if we consider only express engines, we arrive at the conclusion that the main object of the increase of horse-power is to maintain as high as possible the tractive force at full speed or to allow even heavier trains to be hauled, the maximum speeds not being much raised. But at the same time it has made it possible, it is true, to increase the speed of previously heavy and slow passenger or mixed traffic trains to start more quickly and to avoid the undesirable use of pilot engines.

Here the special characteristics and conditions of the working of the locomotive are well illustrated. When it arrived at a state in which it had almost attained perfection, as far as speed is considered, and had acquired most of its modern features, the marine engine was yet in its infancy. The improvements made in the marine engine in the last seventy years while directed mainly to passenger vessels and warships, resulted in giving much greater speeds. In this case the means of obtaining greater power constituted only the solution of a part of the problem; the weight per horse-power had to be much reduced. Reduction in weight was secured in the locomotive by its special boiler and by the intense induced draught created by the blast, which is to-day greater than that employed in any other type of prime mover. Furthermore, the question was far more complex for steam vessels, the power being proportional to the cube of the speed. However, the increase of power of the locomotive, mere speed being neglected, has also required a long period of evolution, perhaps because it was not wanted before.

Heavy and powerful engines give many facilities, but they have a bad efficiency from all points of view, even financial, when they do not haul trains corresponding to their capacity. A low rate of combustion and evaporation is contrary to the principle of the locomotive. If a given railway possesses an excessive number of these powerful locomotives many of them will not be well utilised. Furthermore, when engines with a very large grate area have to stand by under steam, often for prolonged periods, they uselessly burn more fuel than smaller engines.

It is to the credit of British superintendents that they have always endeavoured to make the best of engines—kept, of course, in very good condition and working order—that would elsewhere be considered as not powerful enough for the traffic, but they are assisted by the excellent quality of the fuel and the drivers have been trained to get all that is possible out of their engines.

The necessary increase of power of locomotives is principally the result of three things: the necessity of running heavier trains; the possibility of employing greater axle loads, thanks to heavier rails and better equipment of the track; and raising the boilers so as to obtain greater grate areas and heating surfaces.

The development of the locomotive is thus due to a change in old ideas and to the disappearance of some prejudices. It has thus been enabled to meet the limitations imposed by the special conditions of its duty on rails—the narrowness of the gauge and the necessity of not exceeding an appointed length of wheel base. The improved equipment of the permanent way has had a favourable influence upon design by allowing a great adhesive weight on a minimum number of coupled axles to be used. But the coupling of wheels involves, for many known reasons, a loss of mechanical efficiency, of flexibility, and of easy running. Therefore, to obtain a given tractive effort, the best result is obtained with the minimum number of coupled wheels, and those of the British superintendents who kept to single engines, as long as an adhesive weight of 19 tons to 20 tons, with the help of steam or air sanding apparatus, was sufficient, were entirely right. A classic example, which no other country could show, is given by the remarkable performance of the old Midland single engines (Mr. Johnson's) which always surprised foreign engineers, on the rather difficult line from St. Pancras to Nottingham, with a load of at least 230 tons of bogie coaches at an average speed of 53 miles an hour, upon a consumption of good coal not exceeding 23 lb. per mile. That is certainly a record which speaks highly for a type of engine which modern weights have rendered useless. But it would not have been possible without a first-rate permanent way, so smooth and even that it reduced the resistance of the vehicles as compared with the results obtained in other countries.

Whilst on this subject, I think it interesting to note the remarkable arrangement of the single Bristol and Exeter engines of 1853 (Pearson's), having one pair of large driving wheels (9ft.) between a leading and a trailing bogie. If any engineer wanted to-day, after seventy-three years, to build an engine especially adapted for the highest speeds, he could not do better than follow the same design but with improved dispositions. But the time is no more when mere speed is the aim of locomotive engineers; the conditions of traffic have altogether changed. Single large wheel engines were an aristocracy doomed to disappear in our days.

The loss of efficiency pointed out above is greater as the number of coupled wheels increases. Whence the advantage of heavy axle loads when the permanent way or bridges allow them. A modern Consolidation engine, in the United States, where the load allowed per axle attains now on some lines 33 tons, will have an adhesive weight of 130 tons at least. In Europe, the equivalent engine would require seven coupled or driving axles, with a load of 18 tons per axle, and could only be built on the Mallet, Fairlie or Garratt systems. But Great Britain, France and Belgium are the only European countries, I believe, in which loads of 18 tons to 20 tons are commonly allowed per pair of wheels. The weight on driving or coupled axles is not only limited by the strength of the permament way or of the bridges. The wear of tires increases rapidly with the load on them; high tensile steel is a remedy for the tires, but then the wear and tear is carried back to the rails, and it is well known that, despite the progress of metallurgy, very hard steel rails are dangerous and liable to break. The weight per axle of many American engines seems really very high if we consider it in this light, but then the breakage of rails is probably also high.

A 4–6–2 American locomotive may have an adhesive weight of 90 tons to 100 tons. For British or French engines of the same type, the corresponding figures would vary between 55 tons and 60 tons. When two French railways needed, for hauling long distance expresses which every day grew heavier, engines having an adhesive weight exceeding 60 tons, they had recourse to eight-coupled engines—Mountain type 4–8–2—the most powerful in Europe to this day though they have a tractive force inferior to the modern 4–6–2 engines in the United States of America; permissible axle-loads influence, to a great extent, the choice of wheel arrangement.

Now, it must be noted that the whole of the adhesive weight, or at least the greatest part of it, is only necessary for starting trains or ascending heavy gradients, particularly if the atmospheric conditions are

unfavourable. Thus, taking the case of a locomotive having eight wheels coupled—"Mikado" or "Mountain" type—and hauling express trains on main lines with stops placed at a distance not less than 100 miles apart, for example, this engine will use its total adhesion for a very small portion of its course. When the speed has reached a determined figure, one could uncouple two of its axles without inconvenience; on the contrary, if the thing were possible, the engine would run more freely. Here the distinction to be made between the power and the tractive force is obvious; this last force being, in some measure, static. In one word, the tractive effort which can be usefully applied, is, as well known, a function of the adhesive weight, of the volume of cylinders, of the steam pressure and of the diameter of the coupled wheels, but the available power resides entirely in the capacity of the boiler and in the weight of steam produced in a given time. This is so true that, on many British railways, single, four and six-coupled engines—these last considered as goods locomotives—have the same boiler, though having to develop a very different tractive force.

The development of the locomotive, since the beginning and more than ever of recent years, resides in the increase of steam production of the boiler. When considering old engines, and especially those of the earliest period, one is struck with the extremely small power of the boiler, and the failure of many prototypes had sometimes no other origin than the misappreciation of this important point. For instance, let us consider a "Pacific" locomotive having a tractive force of 33,000 lb. (15,000 kilos.) and a boiler and cylinders corresponding to a power of ing. its speed being only 3·28ft. (1·00 m.) per second, 1800 H.P. at the draw-bar. When the train is just started and the engine exerting all its pulling force, the power developed will be only 200 H.P., and a very small boiler would be sufficient. As the speed increases, the fraction of adhesive weight used or the pull at the draw-bar decreases. When this speed reaches 56 miles per hour (90 kiloms.), or 81·62ft. per second, the tractive force cannot be more than 11,905 lb. (5400 kilos.) corresponding to a power of 1800 H.P. at the draw-bar, the boiler being then pushed to the utmost. The tractive force is thus 36 per cent. of the initial one, and when the speed attains 62 miles (100 kiloms.) the tractive force cannot exceed 8000 lb. (3700 kilos.), or about 24 per cent. of the initial pull; the engine could then haul the train, had it four-coupled axles. Whence the well-known paradox concerning the locomotive, namely, that its power increases as the draw-bar pull decreases, for a given engine and train, of course; in other words, the power varies in the inverse ratio of the effective mean pressure on the piston, the piston speed increasing faster than the effective pressure decreases.

The locomotive is the only steam engine working in such conditions. The volume of the cylinders, calculated in proportion to the adhesive weight and for starting, is far too large for running at a certain speed, whence the necessity of notching up. Moreover, there exist no passenger or even goods locomotives that could stand working at full, or nearly full, admission for many miles, not only because the boiler would not have a sufficient capacity, but also because the motion would be subjected to greater strains and stresses than it is designed to bear for a long period. The bearings, brasses, and generally all the parts subjected to friction and pressures, especially the connecting and coupling brasses and the slide bars, have very small areas, quite out of proportion with the area of the piston and the working pressure. This fact is particularly obvious when the motion of a locomotive is compared to the working parts of a marine engine designed for the same number of revolutions and the same power. Though not evident *a priori*, the heaviest duty service, at least for the mechanical parts of the engine and the frame, is the hauling of slow and heavy goods trains, or pusher service, since the engine exerts, normally, a greater proportion of its tractive force, and the effective mean pressure on the piston is greater than with express engines, though the horse-power developed may be less. I have always noted more hot connecting-rod brasses and driving axle bearings, or even cracks in the frames, on powerful goods engines than on express locomotives. Heavy-duty service, which involves the greatest stress on the working parts of the locomotive is, in many cases, only possible without damage, for a limited number of miles without stops.

(To be continued.)

Institution of Naval Architects.

No. III. *(Conclusion).**

THE first paper taken on Thursday afternoon, March 29th, was entitled "Further Notes on the Relative Strength of Fine and Full Cargo Vessels," and was written by Mr. E. Leslie Champness and Mr. Frank McAlister. Sir John Biles was in the chair. The following is a short synopsis of this paper:—

RELATIVE STRENGTH OF FINE AND FULL CARGO VESSELS.

This paper deals with a longstanding problem of a somewhat controversial nature, namely, whether ships of fine coefficient may be built with lesser scantlings than ships of full form. At the present time it is generally conceded that, considered statically, full-formed vessels do experience higher bending moments in still water and amongst waves than finer vessels. On the other hand, it is equally understood that if the alteration of bending moments caused by heaving and pitching, generally referred to as dynamical effects, are taken into account, the additional bending moments will be greater for the finer vessel than for the full vessel. In the paper it is sought to throw further light on this subject by making a comprehensive survey of the bending moments experienced on investigation, which has extended over a number of years.

A series of five 400ft. ships of the cargo type of the same principal dimensions has been taken; and varied only in fullness of form. The bending moments experienced have been calculated on certain stated consumptions, both for still water and waves, two conditions of loading—the most severe possible for hogging and sagging, excluding any freak loading being considered. The fluctuation in bending moments was first considered, statical conditions, and then the effects of wave structure—Smith correction—and heaving and pitching were taken into account. The results, which are fully given in tables and curves, are regarded by the authors as strictly comparative in nature.

Mr. Champness, in introducing the paper, said he felt that some apology was due for presenting in 1928 the results of a research scholarship of 1915. The results were completed five or six years ago, but the necessity for pursuing a more or less commercial career had made it impossible for him to continue the work. His colleague, Mr. McAlister, however, kindly stepped in some months ago and completed the outstanding investigations.

Mr. J. Foster King said the authors stated that a material subjected to tests over a range of, say, 12 tons would ultimately fail under alternate stresses, and the paper had been framed on the assumption that that was a right and proper standard for analysing the stresses for which ships were designed. Personally, he was a little sceptical on that point. It was perfectly obvious that if a ship was designed so that she was always subjected to stresses in one direction, say, of 12 tons, her life on the water would be very brief, and it was particularly important to know the maximum stress on either one side or the other. It was known from the full-scale experimental data that if stresses of the order of 6 tons occurred either in compression or tension, there would be failure in a more or less degree in various parts of the structure, and more particularly in the parts of the structure subjected to sudden alternations in stress due to the section of the ship.

Dr. A. M. Robb said that the most important point arising out of the paper was that the authors, in endeavouring to be fair to the other point of view, had seriously overstated the case for the additional sagging moment on the fine ships, and it could reasonably have been stated that the paper deliberately overstated the sagging effect.

Mr. T. R. Thomas said that the one point which must not be overlooked was that the ballast condition is the limiting factor in modern cargo vessels. The ballast condition which the authors worked on in the paper was by no means the worst condition that was likely to be met in ordinary service.

Mr. E. F. Spanner demonstrated by means of sketches how the stresses in the section of a vessel must vary as between the portion of the vessel above the water line and that portion below, owing simply to the water pressure which was on the plating in one case and relieved from the plating in the other. He had never seen an investigation which took any account of that, and there was room for one. He believed that a great number of cases of eccentric loading, if analysed by taking account of this variation of lading, would lead to a definite equation which was not of the envelope form suggested by Mr. Foster King on the previous day.

Dr. E. V. Telfer said that we seemed to have reached rather an *impasse* in the development of the subject of the relative strength of fine and full cargo vessels, judging by the case made out by the present authors for the lighter stress coming on the fine ship and the statements made by Mr. Foster King in his paper on the preceding day. It seemed possible that the speed must have some physical influence on the bending moment, and he therefore suggested, as a possible line of research, the co-relation of the work done by the authors with the ideas of Mr. Foster King. The sooner the controversy was put to sleep, the easier would be the task of developing naval architecture.

Mr. J. Lockwood Taylor expressed the view, in relation to the standard assumptions made in longitudinal strength calculations, that the homogeneous loaded condition is not actually the worst that is likely to be experienced by the ordinary trader. The authors made the interesting suggestion that attention should be directed to the range of stress rather than to the actual stress. That would enable naval architects to neglect entirely the weight distribution, but whether that would be permissible might be open to question.

Mr. Champness, replying to the discussion, said that the next step, if another was necessary to proceed with such work, was that some effort should be made to track down why the theoretical assumptions did not seem to fit the facts. The classification societies should try to put investigators on the right lines in an endeavour to make the two things come together.

The Chairman, in proposing a vote of thanks to the authors, suggested that a solution of the difficulty might be arrived at by an investigation of stresses and strains at sea, which, it would be agreed, was long overdue.

A paper, entitled "An Experimental Comparison of the Performance of Model Propellers Working in Air and in Water," was then presented by Mr. W. Sprague. It is summarised in the following:—

MODEL PROPELLERS WORKING IN AIR AND IN WATER.

In this paper the author describes experiments carried out at the National Tank and in the wind tunnel at the National Physical Laboratory. Three screws were tested, two of which were representative of average merchant ship practice, and the other a two-bladed air screw. After dealing with the theoretical side of the experiment, the actual arrangements are described, and the corrections made to the measured forces discussed. The results of the experiments are presented as curves of thrust coefficient and efficiency, the water curves being superimposed on the air results for each screw.

The results of the comparison can be summed up by saying that there is substantial agreement between the values of the thrust coefficient over the practical slip range, *i.e.*, where the thrusts are of fair magnitude, at all speeds of advance, and that at the higher speeds the same may be said of the efficiencies. The lower speeds, however, show varying discrepancies between the efficiencies. These may be due in part to experimental errors, as the measurement of small torques is a very difficult matter, but in part it is no doubt due to what is known as scale effect.

Dr. E. V. Telfer said that, up to the present, four 1851 Scholars had contributed to the Institution's "Proceedings," which was very creditable, and, speaking with due modesty as one of them, he thought Mr. Sprague was to be congratulated upon the subject he had taken up for his research. The major issue raised by the paper was propeller scale effect. From the author's results there might be some sense of comfort because he showed that the scale effect was not very much. He did not suggest that these particular propellers were specially chosen—it was quite likely that they were taken just as they came along; but there was considerable evidence that scale effect, particularly on cast iron propellers, was much more serious than was represented by the author's diagrams. Even the author, however, showed that the scale effect produced a difference in efficiency from 5·5 up to about 6·8; in other words, there was a difference of plus or minus 10 per cent. It was, therefore, satisfactory to know that the subject of propeller scale effect was being taken up. When it was realised that it existed, methods of definitely taking it into account would be devised.

Mr. M. P. Payne said that the experiments revealed rather large differences between the thrust coefficient and efficiency for the same propeller when tested in air and water at the same Reynolds number. The comparison of such results was of considerable difficulty. Tests of the same screw in water in different establishments, where every attempt was made to correct for forces introduced incidental to the methods of support and drive of the screw, and where there was no question of the applicability of Rayleigh's Law of Dynamical Similarity, sometimes revealed differences which, while perhaps not very important as determining the thrust and torque of the screw, received enhanced importance when the subject of the experiments was comparative. In the experiments described in the paper, the conditions of experiment in air and water had been made as nearly identical as was possible, the corrections being thereby reduced to a minimum. Correction to thrust, however, amounting to 35 per cent. slip, to 2 per cent. for the propellers when tried in air, and 5 per cent. when tried in water, were necessary. Considerable caution was therefore necessary in attributing variations which occurred primarily to difference of media.

Professor C. M. Carter said that the probable difference of fluid motion in the tank and in the wind channel accounted for the apparent scale effect. So long as the Reynolds number was the same for geometrically similar bodies in different fluids, the scale effect did not exist, provided that the motion was turbulent in both media.

Mr. W. Hamilton Martin said that the tests of the two-bladed air screw, both in air and water, showed encouraging results. The disc area ratio was 0·084, which was low as compared with 0·431 and 0·446 of the other water type screws tried. If not already contemplated by the author, it would seem worth while to test a propeller of such aerofoil shape in water having an equal disc area ratio and diameter as the others for which it would be necessary to increase the blade number to six of proportionately narrow section.

Mr. Sprague briefly replied.

Sir William Berry (Vice-President) was in the chair at the evening meeting on Thursday, March 29th, when the first paper presented was one on "Stresses in Hulls of Stranded Vessels," by Professor E. G. Coker. The following is a brief *resumé* of this paper:—

STRESSES IN THE HULLS OF STRANDED VESSELS.

The loss of the motor cargo-boat "Lochmonar," which ran aground early in December last at the mouth of the Mersey and broke her back with a cargo on board of an estimated value of £400,000, is an interesting, if lamentable, case of the failure of a ship's hull under abnormal conditions of loading which, possibly, were never contemplated or taken into account by her designers. This vessel was 485ft. long and 39ft. moulded depth, with a bridge 153ft. long on the awning deck. According to photographs taken at the time, this structural failure took place immediately forward of the captain's bridge, where the hull plating above the level of the main deck is reduced in height by a few feet, and the discontinuity of section is rounded off by a curve probably of circular form. The fracture in the ship's hull appears to have occurred at or near the join of this curve with the forward and lower part of hull plating, and extended almost vertically for a distance of many feet, the two parts of

* No. II. appeared April 6th.

the stranded vessel showing a deep vertical V-shaped gap of small angle.

By the application of his well-known method of the photo-elastic investigations of stress distribution to two transparent beams of rectangular section having a discontinuity on the upper edge, the author shows that greatly increased stresses occur just a little in front of the radius. The beams tested had a thickness of 0·199in. and a depth of 0·985in. and 1·250in. The discontinuity consisting in one case of a quadrilateral arc of $^{7}/_{32}$in. radius and in the other of $^{1}/_{4}$in. radius joined to the upper contour by a vertical part. When supported on rollers and loaded by weights at their ends to give a uniform bending moment of 62·4 inch-pounds, the stress was observed by the usual optical methods. The local increase of stress at the point referred to was shown to be of the order of 41 per cent. for the $^{7}/_{32}$in. fillet and 69 per cent. for the $^{1}/_{4}$in. fillet. The results are plotted in the form of a diagram which the author hopes will afford some guidance as to the rise of stress likely to be found in similar cases, and to demonstrate the necessity of strengthening the hull of a ship at such discontinuities, since in any case if this part of the contour is at the highest part of the hull it must be subjected to the maximum stress which can occur.

Dr. A. M. Robb, opening the discussion, said that as far as his experience went the first sign of trouble at the discontinuities was overstrained rivets, and that was characteristic of all discontinuity troubles as far as he had seen them. The early stages were accompanied by over-strained rivets, which indicated a tendency to slide, and from that point of view it rather seemed that Professor Coker's results had, if anything, understated the case. At the end of the paper, however, the author expressed an ideal which was hardly attainable.

Mr. T. R. Thomas gave some account of experiments carried out about eighteen months ago on a vessel 425ft. long. The forehold and the aft hold were filled with water and a bending moment of about 66,000 foot-tons was introduced, which was about two-thirds of what theory would expect in service at sea in accordance with the standard calculations, and by means of eighteen strain meters the strain on the ship was measured in that condition and under several other conditions. He could not at the moment give full details, but the results confirmed what the author had said. There was a distinct patch of maximum stress which, as the author had pointed out, did not occur in the position one might have expected. There were very distinct signs in the hogging condition of a disturbance of the riveting of the bow rail, but whether that was due to the proximity of a butt he was not sure.

The Chairman said that the paper extended our knowledge of the nature of stresses at the particular parts of a vessel which had been mentioned where there was some discontinuity, and the practical man endeavoured to overcome the difficulty by avoiding a right angle bend or a curved bend. Everybody liked to get the shear strakes with nice straight edges on the top, but in the naval service there was usually a breakdown at about the beginning of the aft turrets where a deck was very often dropped, and care had to be taken to avoid having anything in the nature of a straight drop down or even a curve. In the early days it was a common thing in the destroyers to find signs of strain where the foc'sle joined the upper deck, and the endeavour was made to get the upper deck shear strake to run right through continuously, to make the plate above thinner and then reinforce it with a bar at the top to deal with the little side strain there. During the war a considerable number of our ships touched the shore, but he could not remember any case of the breaking up of a ship owing to discontinuity of the structure.

Professor Coker replied briefly.

The final paper taken on Thursday, March 29th, was one on "The Effective 'I' of H.M.S. Wolf," by Mr. G. H. Hoffmann. The following is a short summary of this paper:—

THE EFFECTIVE I OF H.M.S. WOLF.

The results of the experiments made upon H.M.S. torpedo-destroyer "Wolf" by the Committee on Destroyers, show that the I/y calculation cannot be relied upon to give accurate quantitative results even for known bending moments, but that experimental coefficients must be used in order to obtain agreement between theoretical and actual stress values. It was also definitely proved that the stress estimates on the I/y method only can possess comparative value. The late Marine-schiffbaumeister Pietzker, of the German Navy, introduced a new method of estimating longitudinal stresses in ships, based upon the "Wolf" experiments. He laid down, however, as his basic principle that something must have been wrong with the moment of inertia calculation. In calculating the effective I, Herr Pietzker takes the plating along the longitudinal members, whether they be continuous or intercostal, if they only stiffen the plating against buckling—to be fully effective for a width of forty to fifty times its thickness, that is twenty to twenty-five thicknesses on each side of the stiffening member. The remainder is considered to be fully ineffective.

The author gave a paper in 1925, in which he showed that at least in the case of the "Wolf" Herr Pietzker's theory was rather on the safe side, and, further, he attempted to explain the discrepancy between calculated stress and measured steam. In the present paper the author presents the results of further research work which had led him to formulate a new theory with regard to the effective I of H.M.S. "Wolf."

The theory advanced can be summarised as follows:—

I. It is still assumed that the strain on any of the fibres is directly proportional to its distance from the neutral axis.

II. In deducing the stress from the strain, the following rules must be observed:—(*a*) Herr Pietzker's fifty thicknesses are always considered as fully effective, whether in tension or in compression; (*b*) plating in tension is always considered to be fully effective; (*c*) plating in compression, not affected by water-pressure, is considered fully effective so far as it is strained below its resilient force as indicated by Euler's formula for columns having fixed ends, and when strained above that limit is considered to contribute that resilient force to the moment of elasticity, whatever the strain; (*d*) for plating in compression, at the same time affected by water-pressure, the relation between strain and stress is calculated from Koch's formula.

The theory is presented in relation to all available strain indications taken on the "Wolf," and the calculations are plotted in curve and diagram form. In an appendix it is shown how it can be used for actual strength calculations for a new design.

Sir J. Biles said that the calculations in connection with the "Wolf" were made about twenty-four years ago, and he was quite prepared to change his opinions upon the deductions that were made at that time. There was no finality in such matters, and naval architects were grateful to the author for having carried the study so much farther. He gathered from the present paper that when the author corrected the value of I he did not make any very appreciable difference from the results obtained by the Committee which was trying to find out whether the destroyer had been subjected to excessive strains or not.

The Author said that the difference was not very great; 10 per cent. or 15 per cent. would be the greatest error.

Mr. S. V. Goodall said that he did not feel convinced that the author had succeeded in accounting fully for the discordances in the "Wolf" results. His own conception of Mr. Hoffmann's paper was that he, as it were, took the onus of those variations from the modulus of elasticity and put it upon the moment of inertia, but the justification for doing so, so far as he could see, was only partial. It was worth while recording that sometimes stresses calculated by the latest methods were alarmingly high for ships that had proved amply strong on service; he could recall one case of a ship, that had never given the slightest indication of weakness on service, having a calculated stress of estimating above the yield point, which only served to show how necessary it was to keep in mind the fact that, in calculations, mathematicians were only making comparisons and not necessarily arriving at figures indicating actual facts. In fact, he sometimes felt that there was a danger that the more we theorised the more timid we were likely to become.

Mr. L. Woollard said that this further investigation by Mr. Hoffmann of the "Wolf" results provided a solution to a difficult problem in a convenient form. In modern naval design, and probably to some extent in mercantile ship design, the necessity for reducing structural weights to a minimum had become very acute. It was possible to reduce weights by using steel of higher tensile qualities. Unfortunately, strength against compression could not be improved by any such means; all that could be done was to redesign the structure so as to reduce to a minimum those portions which were not fully stressed under compression.

Dr. E. V. Telfer said that in Danzig a small ship model was being made and various shear and other tests were to be carried out, whilst at the Hamburg tank—a commercial undertaking and not a Government subsdised undertaking—a steel vessel 50ft. long was to be built and tested; in that way it would be possible to get on to many problems that would have been solved by the "Wolf" had the "Wolf" been in dry dock.

Mr. Hoffmann briefly replied to the discussion, and in reply to Mr. Goodall said that it should not be taken that he was not conversant with British Admiralty practice. What he was trying to do was to help people outside British Admiralty practice to face problems which the British Admiralty had solved with very great success in the case of the "Wolf."

The President was in the chair during the meetings on Friday, March 30th, when the first paper to be taken was entitled "Some Modern Developments in Rigid Airship Construction," by Lieut.-Colonel V. C. Richmond. This paper is given in full on page 410.

DEVELOPMENTS IN RIGID AIRSHIP CONSTRUCTION.

In the course of his paper, Lieut.-Colonel Richmond showed a series of lantern slides, which illustrated very clearly some constructional details of R 101, and the very thorough tests which have been made on parts of the assembled structure, and to which reference is made in the paper. The illustrations on page 399 are reproduced from Air Ministry photographs for which Crown copyright is reserved, and are representative of the views Colonel Richmond showed. In the first pair of engravings a typical Zeppelin girder joint, taken from one of the airships shot down during the war, is shown alongside a similar arrangement of girders in R 101. The second pair of engravings illustrate the construction of a main longitudinal girder, and another girder joint. The screwed terminals on the ends of the bracing wires for the adjustment of their tension may be noted in the right-hand view; also the simple duralumin die stamping used for the joint. In the third pair of engravings we show one of the main transverse frames of R 101 arranged for test. The test bay is fixed on the door of the shed and is loaded with 3 tons on one of the joints. Alongside this view is one of the same test bay, after it was detached from the door of the shed and was inclined for the pitching test, with the gas bag inflated. The parachute wires for resisting the end pressure of the gas bag may be noted. They are fully described in the paper.

Group Captain Fellows said that the initiators of the airship programme realised very clearly that before airships could become commercial it would have to be proved that their hulls could be built sufficiently robust to withstand all the stresses they could be put to, both in flight and at the mooring tower. In an endeavour to do that a great deal of experiment and research had been carried out, and the primary motive of the work was to prove that the rigid hull could be built strong enough. The Air Ministry consistently had before it the idea of safety first. For that reason those concerned with the construction of the new airship had not been urged to hurry unduly. They had been allowed to proceed cautiously, and he believed it would be agreed that that was the right policy.

Mr. H. G. Williams remarked that the paper amply justified the policy which had been pursued in continuing airship construction on the scale that was being followed. As regarded the new designs, he was glad that we had got away from the Zeppelin design, which he regarded as dreadful. The design and construction of airships was such that the stresses could be ascertained with very much greater accuracy than in the case of ships, and therefore lower factors of safety could be adopted, because in the cases of ships and some other structures the stresses were really incalculable.

Mr. E. F. Spanner, after criticising the design, considered that undue risks were being run in building R 100 and R 101 to so low a fineness ratio as 5·5, and he failed to see that there was any sound justification for taking those risks.

The President asked Mr. Spanner to send in for the "Transactions" the remainder of a very detailed criticism of the structural arrangements of the new airships which he had prepared.

Mr. Spanner, in agreeing to do so, said that his object in making these criticisms was because he considered that rigid airships had no future, and because he was anxious that we should not be let down by obvious faults in the designs of the new airships.

Colonel the Master of Sempill (President, Royal Aeronautical Society) said that it was fortunate that we had now got something approaching a definite airship policy. It would have been better for the development of the two British airships, the one at Cardington and the other at Howden, if there could have been fuller collaboration between the two technical staffs concerned. There had, as a matter of fact, been a sort of system of water-tight compartments which could not be for the good of the eventual development of British airships, and he hoped that the barriers had been broken down, and that there was the fullest possible collaboration between the author's staff and the staff of the Airship Guarantee Company at Howden. Similarly, it would be interesting to hear if the author and his staff had the use of the thirty years' experience of the Zeppelin Company.

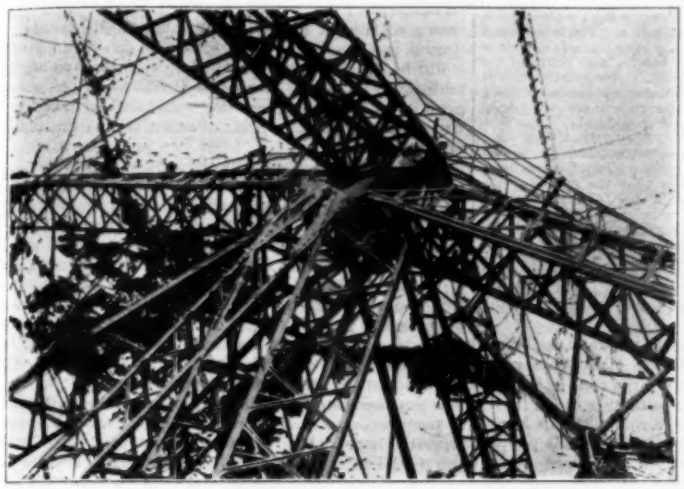
Major Scott said that he was probably more interested in this airship than anybody else, as he hoped to have the honour of flying her. From that point of view he had watched Colonel Richmond's methods, and the thoroughness with which everything had been done, and he felt confident that when he took the ship out, he would be taking out an absolutely sound and strong airship, and also one that would be thoroughly stable. The previous airships of very small diameter were much more difficult to control than the later R 33. The whole of his experience was that the shorter airships are much easier to control than the very long ones. Mr. Spanner was quite wrong in the impression that airships were normally flying at 12 deg. inclination. An airship was very often a little bit down at the bows or a little bit up, but as a rule it was about 2 deg. either way. He believed the conditions to which Mr. Spanner had referred occurred in a trial, and were introduced deliberately.

Mr. L. V. Southwell said that for the first time since the Air Ministry design was started at Cardington, information had been given which enabled the outside world to assess, not merely the external appearance of the ship, the spaciousness of its dining accommodation and the comfort of its berths, but the efficacy of those structural arrangements upon which its safety would depend. It was a sound instinct for Colonel Richmond to choose a meeting of this Institution as the occasion for these revelations; for his problems, though new, were similar in kind to those which confronted the naval architect.

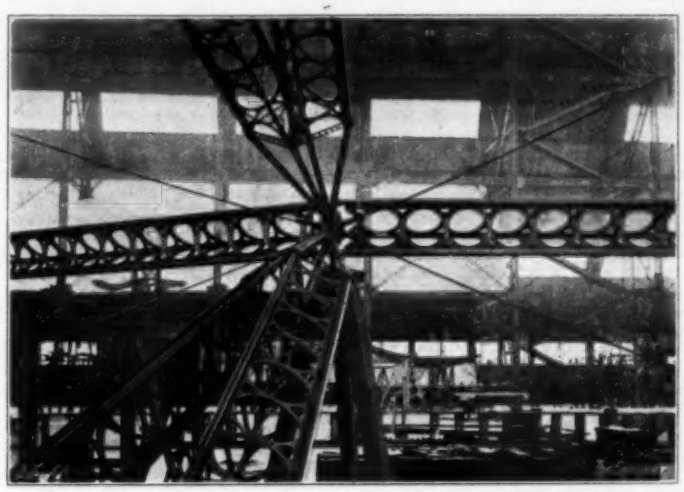
Wing Commander Cave-Brown-Cave said that as he served on the court of inquiry concerning the accident to R 38 and also on the subsequent investigation by the Accidents Committee, he realised very acutely the extraordinary difficulties under which the unfortunate airship was completed and tried. One of the greatest difficulties the late Mr. Campbell must have encountered must have been the absence of any means of determining what, in point of fact, were the stresses produced in the ship. During the trials, certain members failed, but it was very doubtful why they failed. Owing to the use of strain meters, it would be possible during the trials of R 101 to measure numerically, with very considerable accuracy, the actual strains produced on the main members of the ship. In other words, as the trial flights were carried out in progressively worse weather conditions and at progressively greater speeds and angles of helm, the designers would be able quantitatively to observe the stresses produced in the main members. That was a state of affairs which was ahead of anything obtained in most branches of engineering.

Colonel Richmond, replying to the discussion, said that he found it difficult to follow Mr. Spanner's line of argument with regard to the non-rigid airship. He failed to see why it should be thought that a non-rigid ship, which would bend, should be easier to make than a rigid one. Again, Mr. Spanner seemed to

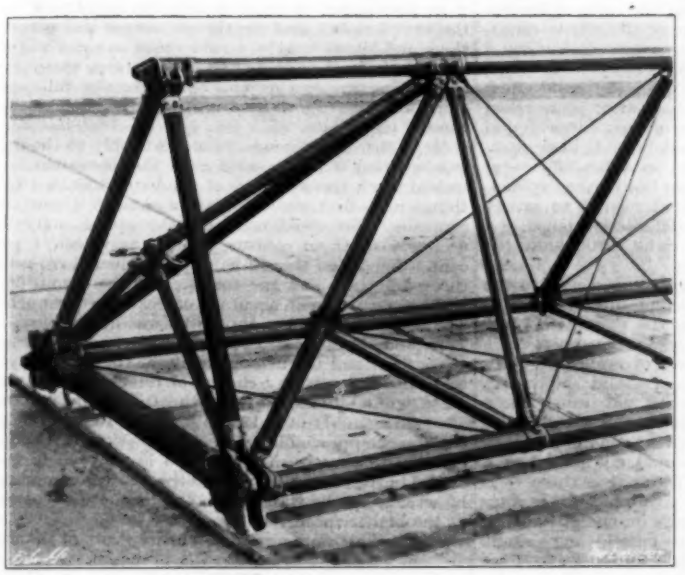
THE RIGID AIRSHIP R101—CONSTRUCTIONAL DETAILS



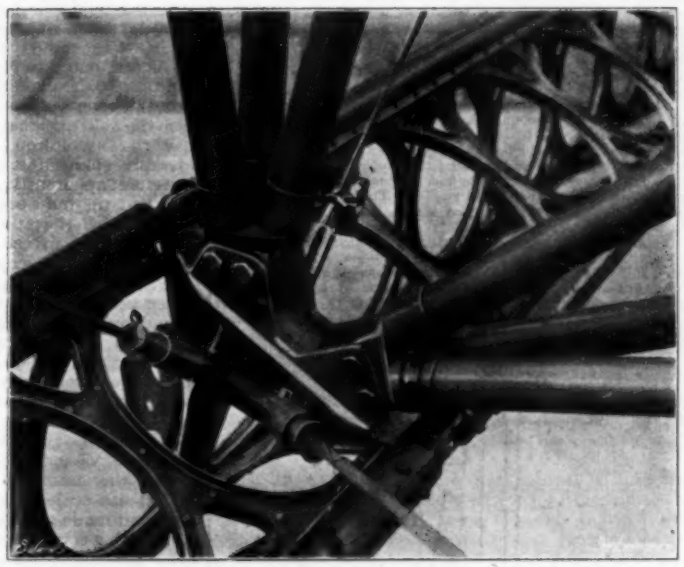
TYPICAL ZEPPELIN JOINT



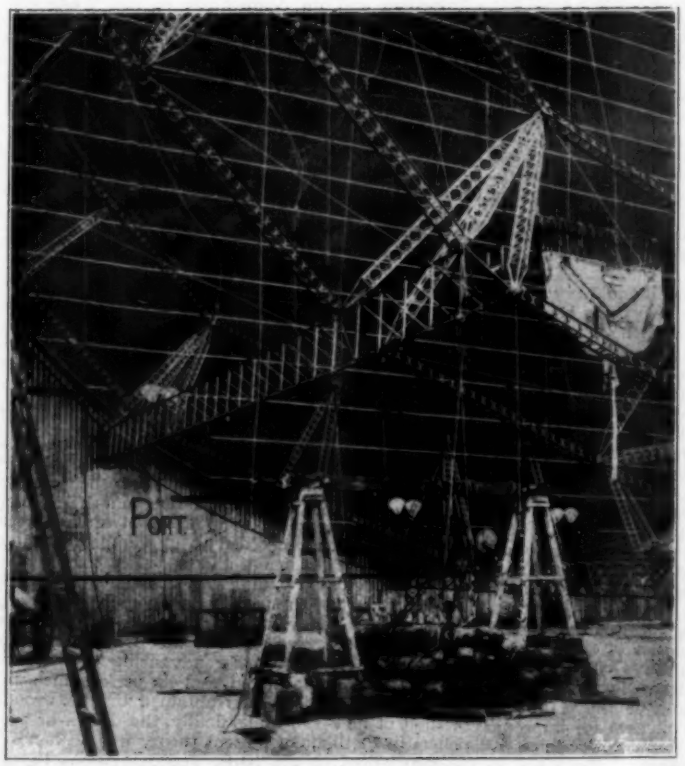
SIMILAR JOINT IN R.101



MAIN LONGITUDINAL GIRDER



JOINT SHOWING BRACING WIRE TERMINALS



LOADING TESTS—GAS BAG NOT IN PLACE

TEST BAY OF AIRSHIP INCLINED FOR PITCHING TEST

think that the "Bodensee," because she was short and fat, would be more easily spun, through her low inertia, owing to the effect of local gusts; but that argument was not quite sound. If the airship was a sphere, he thought the sphere would have little tendency to depart from a given direction because of her symmetry. Surely a gust striking the tail of a long airship would have a greater leverage and tend to turn the airship off her course. As to the degree of pitch, if Mr. Spanner had travelled in an airship he would know that the angle was in no way a discomfort to the passengers, and would not spill a cup of tea. Colonel the Master of Sempill had raised the question of secrecy, but his own personal attitude was that it would have been useless to publish all over the world what it was hoped to do before anything was done. He preferred to wait until certain results had been achieved, and he believed that would be accepted as a wise policy. As to collaboration, his whole principle had been to obtain the collaboration of anybody who could usefully assist. The fullest endeavours had been made to secure the co-operation of the Zeppelin Company, and that had been done, and he had spent many months of continual correspondence with Herr Jaray, who was the actual designer of most of the successful Zeppelins.

The other paper taken on Friday morning was one entitled "Experiments on the Propulsion of a Single-screw Ship Model," by Messrs. G. S. Baker and J. L. Kent, and was read by Mr. Kent in the absence of Mr. Baker. An abstract of it is as follows:—

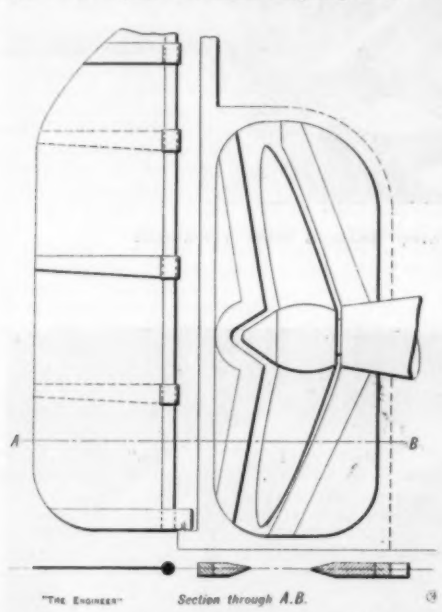
EXPERIMENTS ON THE PROPULSION OF A SINGLE-SCREW SHIP MODEL.

A number of experiments on the efficiency of a self-propelled model of an ordinary type of single-screw cargo vessel have been made at the William Froude National Tank, with the object of investigating the effect on the efficiency of propulsion of a ship when the propeller aperture is partially or wholly closed. In addition, propulsion experiments were made with and without an ordinary plate rudder fixed in position on the rudder post.

The ship model used in the experiments represented on a scale of 1/24·4 a cargo steamer of good average form, with the following principal dimensions:—Length between perpendiculars, 400ft.; breadth, 57ft.; draught, 27ft.; load displacement, 13,350 tons; block coefficient, 0·76; trim, level. The model had an ordinary mercantile stern of elliptic pattern, and was fitted with a metal stern frame and rudder post to which could be attached an ordinary plate rudder. The shape and dimensions of the screw aperture are shown in the accompanying engraving.

The model was propelled by a single four-bladed screw of the following corresponding dimensions:—Diameter, 19ft. 5in.; pitch, 19ft. 6in.; blade area, 132 square feet; number of blades, four; outline of blades, elliptical; shape of back of blade section, circular arc; rake aft at tips, 2ft. 1in.

Two flat metal plates were fitted to the stern frame in such a manner that the space left in the screw aperture, when the propeller was in place, was almost completely closed. These



Arrangement of Closed Propeller Aperture

plates—which were detachable—were of the same thickness as the body post and rudder post, and formed a continuation or extension of the middle line plane. They were chamfered to a fine edge towards the screw, as shown.

The model was fitted with a stern frame and rudder post of usual type, and experiments were made with the model propelling itself at speeds covering a range of 8 to 13 knots for the ship. During each experiment the torque on the shaft, the thrust and revolutions of the screw, and the speed of the model were automatically recorded. By means of the plates described above, the aperture was (*a*) closed forward of the screw and left open aft the screw, (*b*) closed forward of the screw and closed aft of the screw, (*c*) left open forward of the screw and closed aft of the screw. The model was tested in each of these conditions.

It was then fitted with a plate rudder of ordinary type and experiments under conditions (*a*), (*b*) and (*c*) were repeated, with the rudder in a fixed fore and aft position. One other set of experiments was made with rudder, stern frame and rudder post removed, so that the model was then in the condition under which model propeller tests are usually made.

The extent of the gain in propulsive efficiency obtained by closing the aperture aft of the screw over that when the aperture was wholly open can be illustrated by the fact that from 7 to 11 per cent. less power was required to drive the model in the former case than in the latter. The results also indicate that a fin fitted to the stern frame forward of the screw was disadvantageous, while the fitting of a fin plate on the foreside of the rudder post was a distinct advantage. To obtain the full benefit from it this fin must be fitted close up to the after edges of the propeller blades. The rudder itself has the same action as this fin plate, but is too far from the screw for it to be very effective.

One other certainty can be stated, viz., that the surface of the fin being fore and aft cannot accept any thrust—in other words, there is no thrust return obtained from the action of the "whirling" race on these fins.

In the authors' opinion, there is whirling in the propeller race, and this is most emphatic on the centre line. The whirl must tend to develop within the screw, but the after fin does not allow it to develop to the same extent as before, and compels the water to move fore and aft. There is, consequently, better conservation of fore and aft momentum, and less loss in whirling or spiral motion. Above the propeller race there are eddies with horizontal and vertical cores, and considerable cross flow from one side of the ship to the other. This cannot take place to the same extent with the fin in the aperture, and the flow in this region becomes more stable and consequently less wasteful. This opinion being accepted, it follows that the fin may take any form as long as it performs the function of a fin without involving any extra resistance.

In the second part of the paper comparative tests are shown between the propeller already described and a similar propeller alike in all respects with the exception that the blade sections were of approved aerofoil shape instead of circular arcs. The results show a fairly steady gain in quasi-propulsive efficiency for the blade sections with aerofoil shapes accompanied by slightly lower revolutions.

Dr. E. V. Telfer said that was the first occasion on which the National Tank authorities had published results of self-propelled models over an extensive range of speeds. According to the figures in Table I., the propulsive coefficient varied from 0·835 at 8 knots to 0·690 at 13 knots. In the first place, most people would be astounded at the figure for propulsive efficiency at 8 knots, viz., 0·835, but although the form was remarkably good at 8 knots, it very rapidly dwindled away at 13 knots, the difference being about 15 per cent. It might be said, as a consequence of these figures, that the form of the model was a poor one, but the authors stated that the form was a good one. It would also be seen that the ratio of revolutions per knot was constant over the whole range, and hence the reduction of propulsive coefficient could not be attributed to propeller efficiency or load effect. One possible explanation was the wake scale effect over the range of speed, but had wake scale effect been the sole explanation, it would have been found that the revolutions per knot would have considerably changed with change in wake efficiency. Therefore, apparently, that could not be the explanation, and the only argument that seemed to satisfy the case was that there was definite evidence of a negative error in the torque right throughout the whole range of the experiments.

Mr. J. Tutin said that although 40 per cent. of the power generated by the propelling machinery was wasted by the screw propeller, the power that was wasted in the machinery received very much more consideration, yet many types of improved propellers were relatively inexpensive, and shipowners would therefore be very wise to pay much more attention to what was happening at the screw and at the back of the screw than they had done in the past.

Mr. S. G. Visker said that he would not have spoken but for the statement of Dr. Telfer that there were no full-size scale experiments available. His company had made some experiments on one of its ships fitted with a contra-propeller, the vessel being a single screw passenger steamer of 4000 H.P. Trials were run with and without the contra-propeller under exactly the same conditions of trim, and it was fortunate that the same weather conditions prevailed on the occasion of both sets of trials. The results were considerably less than the patentees had promised, viz., 4 per cent. gain with the contra-propeller. During one of the trips two of the side blades cracked and they were removed. The vessel left Amsterdam on another trip with only the vertical blades, but the 4 per cent. gain still remained. New side blades were fitted, and on the next voyage the same figure was obtained. Then the side blades broke again, and it was decided to run the vessel without them. This had been done and the 4 per cent. gain was still maintained. He had always held the view that the advantage was due to the fin fitted to the sternpost, and not so much to the very slight pitch that was in it. His experience confirmed the opinion that results obtained with models held good for the full-sized ship.

Mr. W. G. A. Perring said that it could not be said definitely at the moment that there was no thrust return obtained from the action of the whirling race on the fins.

Mr. M. P. Payne thought the paper served to raise the question of the source of reputed gain in propulsive efficiency associated with the contra-propeller. Such a device when fitted abaft the propeller might well be associated with some gain in efficiency, owing to fining of the sternpost, but that must be regarded as incidental rather than as a primary source of advantage. The action of a contra-propeller, as such, must mainly depend on two causes. (*a*) By a partial prevention of rotation in the race, the flow through the main propeller might be completely altered with consequent modification of efficiency; (*b*) by interaction of blades and race-water making some restitution of thrust for any remaining rotation in the race. It was, however, clear that neither of those causes necessarily led to gain in propulsive efficiency. In the case of (*a*) the main propeller was working under altered conditions, which might or might not be beneficial to efficiency; while in case (*b*) improper shaping of the blades might actually add an element of resistance rather than of thrust. Taking a fin fitted abaft the propeller, it resembled in its action a contra-propeller, probably by prevention of race rotation, but clearly it could not act to make any restitution of thrust, as the authors emphasised, and, subject to gain resulting from improving the stern-post ending, must be regarded as a small element of resistance. In the case described in the paper, the fitting of the fin resulted in a substantial increase in propulsive efficiency. Where such a saving of power could be obtained, it should be worth while to accept additional constructional complications in the stern-post, as well as the difficulties associated with reduced size of the propeller aperture when it was desired to remove the screw.

Mr. H. G. Williams said that the improvement in propulsive efficiency obtained by filling up the screw aperture abaft the propeller in the experiments recorded in the paper was somewhat surprising. While it went some way towards confirming the claims which had been put forward for the saving in power obtained by guide blades abaft the propeller, it, at the same time, to some extent, deprived that saving of power of its most plausible explanation, namely, that the guide blades gave a forward thrust when acted on by the rotating screw race. Apparently, the closeness of approach of the fin to the after edge of the propeller was as important for the improvement of efficiency of propulsion as the shaping of the fin so as to get a forward thrust. Mr. Baker's experiments showed that the model took 7 per cent. to 11 per cent. less power for propulsion when the aperture aft of the screw was closed than when it was left open. He thought Mr. Baker's paper would have been even more interesting than it was if he had given the actual results of the trials, namely, the thrusts, torques, speeds and revolutions measured in the model experiments, especially if he had added to those figures the resistances for the towed model and the thrust, torque and revolutions and speed for the model screw in open water, instead of—or, better, as well as—counting them into efficiencies, revolutions and speed for the full-sized ship. Anyone who wanted to study the paper closely wanted those data.

Mr. Kent, in the course of a short reply to the discussion, said that a good deal of the discussion had turned upon the accuracy of the experiments. The things measured were the model alone, without the propeller, the resistance and the speed and the accuracy of these measurements was within 1 per cent. When the thing was self-propelled there were the revolutions and the torque, and the revolutions were measured to an accuracy of less than 1 per cent. The torque measuring apparatus was a new piece of gear, and it was tested for a period of two or three years first, and the arrangements of the actual tests took into account any change of direction. He was quite willing to admit that the 0·835 was wrong. That ship would run at 12 knots, and at 13 knots there was an inappreciable gain. That would account for the drop between 12 and 13 knots, which was shown in the table. At 8 knots the figure given might be wrong, but he was certain the torque was correct at the higher speeds.

The authors were accorded a hearty vote of thanks.

On Friday afternoon, March 30th, the first two papers, being on a similar subject, were read and discussed together. The President was again in the chair. The papers were "The Vortex Theory of Propellers and its Application to the Wake Conditions Existing Behind a Ship," by W. G. A. Perring; and "Cavitation," by John Tutin.

Vortex Theory and Cavitation.

In introducing the first of the two papers above mentioned, Mr. Perring remarked that although a number of propeller theories had been evolved during the last half century, few of them admit of any simple application, and, therefore, the naval architect was forced to employ other than theoretical methods in designing propellers. In the sphere of aeronautics, however, considerable progress had, he said, been made in recent years, and an airscrew theory had been developed which was fairly readily applied and which led to results agreeing closely with experiment. In the first part of the paper he dealt in outline with the vortex theory of propellers, making reference to the work of Glauert, and to the momentum theory enunciated by R. E. Froude, along with a modified form of the blade element theory which was originally suggested by W. Froude.

He then went on to consider the flow taking place around an aerofoil, after which equations were deduced to enable the complete propeller characteristics to be calculated. A note on the aerofoil characteristics concluded the first part of the paper. The author then proceeded to apply the theory to the open water conditions and to design, also to compare the calculated values with experimental results. The third part of the paper was devoted to applying the theory to the wake conditions existing behind a ship and a particular example was dealt with. The performance of a propeller advancing in a mixed wake was next considered, and its performance was compared with the results obtained by the Froude method of analysis, while, finally, the design of propellers in the light of present theory was dealt with. In appendices to the paper approximations to the equations for thrust and torque are given which are

applicable when the propeller is working near maximum efficiency. The method of carrying out the calculations is also described.

Mr. Tutin's paper on "Cavitation," which was then read by the author, had for its object the development of a method of investigating the conditions under which a propeller will cavitate. Equations were derived for the value of the pressure drop at any point on a screw propeller necessary to produce cavitation, and the maximum value of the pressure drop on the back of the blade element was found under given conditions. An accurate criterion for practical purposes was then derived, and the average value of the inflow over the screw disc and the average value of incidence determined. It was shown that, if at any point the angle of incidence was negative, a cavity might be formed on the face of the blade at the leading edge. Free cavitation was also shown to occur when the inflow was abnormally high or when the blade passed through a region of low wake speed. Such cavitation, the author stated, was liable to produce erosion, since the cavity would periodically form and collapse with the familiar "water hammer" effect on the metal surface. Thrust and efficiency would also be adversely affected. The case of the "Oroya" was considered, and it was shown that the propeller was run under such conditions that, in certain regions of the screw disc, the water was liable to impinge on the back of the blade instead of on the face, with consequent free cavitation. Finally it was shown that in the case of the "Oropesa" the propellers were immune from both these effects.

Mr. G. S. BAKER, in a communication upon Mr. Tutin's paper, said that the general principles used were fairly well understood and, broadly speaking, had been accepted for some time. For the cavitation at large slip angles the author had assumed (1) that he could lump all suction into one broad effect and ignore its variations over the blade; (2) that that suction was such as always to maintain an inflow ratio of ·75, *i.e.*, that three-sevenths the race velocity was acquired before the screw at all radii and all slip angles; (3) that there was no variation of rate of rotation of the propeller shaft; (4) he ignored what was known in aeronautics as the free edge effect, *i.e.*, the falling off of k and efficiency towards the tip of a blade; and ignored outside interference or cross flow. The author could only be justified if none of these items were serious. However, he recommended anyone engaged in the design of propellers to follow the author at least as far as to study the pressure curves on various blades. A great deal was to be learned and some errors could be seen from it.

Dr. E. V. Telfer said that Mr. Perring's paper represented a welcome attempt to apply the developments of aeronautical science to the problem of the marine propeller. In that respect, however, it was perhaps somewhat belated, and he recalled the earlier and more complete work of Fottinger, Kucharski, Horn and Helmbold in Germany, and to a certain extent of Slocum in America. The work of all those investigators was essentially devoted to the marine problem, and all used what was now accepted as the vortex theory. It should be stated that the first enunciation of the principles of the true vortex action of the propeller was due unquestionably to one of their own members, Dr. F. W. Lanchester. The neglect of Lanchester's lead in this country had been appalling. It was astounding to think that Lanchester's first work on the vortex theory was contained in a paper submitted to and rejected by the Physical Society of London as long ago as 1897. Mr. Perring, in his paper, perhaps unwittingly contributed to the perpetuation of this neglect of Lanchester. By follow-Glauert's work there seemed to be a danger of again losing sight of the mechanism of the tip vortex, and to avoid this danger the work of Lanchester, Fottinger and Kucharski should be studied. The most interesting and novel feature of Mr. Perring's work was his further application of the Glauert treatment to a propeller working in a mixed wake.

Mr. C. J. Calderwood said that Mr. Tutin mentioned the figure of 6 lb. per square inch as an average blade pressure, but it was very misleading to speak of average blade pressure. Blade pressure varied so enormously both on the back and on the front of the so-called working face that average pressure had no meaning. The point raised by Mr. Tutin that the pressure distribution should be considered, was very important. Mr. Tutin rather gave the impression that the aerofoil section was worse in that respect than the normal blade section, and the impression was also given that the aerofoil section was a definite section; but, as a matter of fact, there was an infinite number of aerofoil sections to choose from, and in any case where the pressure exceeded 3 lb. or 4 lb. per square inch it was necessary to make a very careful choice of the section to obtain the best distribution for the back of the blade. The effects arising from the fact that the propeller was not rotating at a uniform speed was not stated in any work on that subject that he knew of. No matter what type of engine was adopted, there was always some vibration in the shafting depending on how near the critical speed was approached. How serious that vibration was upon cavitation of the propeller did not seem to be realised, but, in cases that he had measured, the propeller had actually been stationary at times and at other times moving at twice its average velocity. That meant that the angle of incidence at times had probably been somewhere near 10 deg. to 13 deg. negative and at other times something like 14 deg. to 15 deg. positive. The effect of that cavitation upon both the front and back of the blades must be enormous.

Mr. S. G. Visker said that his company had been endeavouring to carry out a series of tests at certain critical speeds on steam engine driven ships. It had been shown that running ships at critical speeds involved a loss of about 8 per cent. with quadruple screw engines running at 90 r.p.m. In one case that was found not to be the case, and the reason was that the speed of the vessel corresponded to the revolutions. In other instances the reverse was the case, and then there was a loss of speed. He could only account for the fact by the propeller getting slack of the water; it lost touch with the water at certain moments and therefore the horse-power available for driving the vessel was decreased with a corresponding decrease in the speed.

Mr. M. P. Payne, discussing Mr. Perring's paper, said that the importance of the interaction between propeller and hull in a ship rendered the problem of propeller design more involved than that of an airscrew, and the difficulty of determining the exact nature of the wake must seriously limit the value of the vortex theory as a means of designing the best ship propeller. The theory as applied to airscrews led to results in close agreement with experiments, but appeared to give the least satisfactory agreement near the blade tips and boss. It would seem, therefore, that in ship screws having necessarily smaller aspect ratios, the agreement with experiment was likely to be less favourable. In applying the theory to a propeller in open water conditions the author had taken, presumably for simplicity, a propeller with a constant ratio of maximum thickness to chord throughout the blade, and comparison had been made in effect with experimental results of propellers whose blade thicknesses increased uniformly from tip to root. While the calculated propeller was thus thicker than the experimental propellers over the outer portion of the blade, it was thinner than the Schaffran screw over about 70 per cent. of the blade area and very appreciably so near the boss. It was doubtful, therefore, whether the high effective pitch of the calculated propeller compared with the Schaffran screw could be attributed to a blade thickness effect as stated.

Dealing with Mr. Tutin's paper, Mr. Payne said that in the development of the theory advanced in the paper an inflow factor of 0·75 had been provisionally assumed. Where data for infinite aspect ratio was used the Froude and vortex theories indicated that the ratios should be 0·5. If data applicable to aerofoils of finite aspect ratio were taken an average value of less than the "ideal" one was indicated by experiments. The value assumed for the inflow entirely determined the value of the comparison given in the paper, since the angle of incidence of a blade section was acutely sensitive to it. Reduction in that factor would lead to an increase in the angle of incidence with a corresponding reduction in the local wake required for incipient face cavitation. The criterion for back cavitation was not so sensitive to the value taken for the inflow.

Mr. E. B. Harries, referring to Mr. Tutin's paper, said that the blade sections to which Mr. Tutin applied his theory were at positions only 3 per cent. and 5 per cent. of the propeller radius in from the tip, and it was well known that the blade element theories did not give correct results near the tips. If blade sections were chosen further from the tip, it would be found that they were much too wide to be regarded as aerofoil elements moving in rectilinear paths. He had applied Mr. Tutin's theory, amended in certain respects, to the blade sections B of the "Oroya" and "Oropesa" screws, but with the same result as before, viz., that both ships should be badly cavitating. To test the matter further, calculations were made for a battleship screw in which the progressive speed trial results gave no indication of cavitation. The result was that at even the deepest immersion of the blade element considered, the actual lift coefficient appeared as three times the lift coefficient deduced for incipient cavitation to occur. In view of these conclusions, it was evident that if the theory was applied to the wide blades of, say, a destroyer, where there was evidence that cavitation did occur, it would give results still more misleading. Dealing with Mr. Perring's paper, Mr. Harris said that the author had not mentioned the limitations of the vortex theory of propellers when applied to marine screws. The principal limitation was that, in general, marine screw blades were too wide to be regarded as a series of aerofoil elements moving on straight paths. The vortex theory broke down near the tips of a propeller, and while the discrepancy between theory and experiment on that account was small for airscrews, it must become large for wide tipped marine screws. Considering the propeller performance in a mixed wake, it was doubtful if the theoretical results were very accurate under the conditions assumed. The fundamental assumption made was that in a wake varying across the screw disc, the wake speed could be simply superposed on the apparent speed of advance in considering the action of a blade element. In practice, the action must be much more complex than that. The further assumptions made were that the axial and rotational inflow factors, which vary with angular position, could be calculated at each angular position of the blade by the same method as applied to flow possessing axial symmetry. The results obtained, however, were at least qualitatively true, and it was of interest to consider why the actual relative rotative efficiency was appreciably less than unity. The reason lay in the curvature of the curve of efficiency of a blade element on a slip base, which made the mean value of the efficiency during one revolution of the screw through the variable wake always less than the value for the mean wake. It followed that the Froude relative rotative efficiency and the actual should approach one another at high slips where the efficiency curve flattens out.

Mr. Perring and Mr. Tutin will give their detailed replies in writing.

The final paper of the meeting was one entitled "Statistical Analysis of Voyage Abstracts," by Mr. J. Lockwood Taylor. A synopsis of the contents of this paper is given below:—

STATISTICAL ANALYSIS OF VOYAGE ABSTRACTS.

In this paper the author has summarised the contents of about 300 abstract logs, the primary object of the analysis being to determine the loss of speed under service conditions, as compared with smooth water trial trip conditions. The general objects of such statistical analysis are discussed, after which the author proceeds to the construction of a "frequency curve," showing the number of days on which the speed has been within certain limits on either side of a mean value. Such curves are reproduced for three vessels on the North Atlantic route. The mean speeds of the better and worse halves of the vessel's career during the period under review are calculated, and their difference expressed as a percentage of the actual mean speed of the whole period is taken as a measurement of the "dispersion" of the observations, which is in inverse ratio to the time-keeping ability of the vessel. The dispersion of daily speeds on the North Atlantic run is shown diagrammatically, as is also the dispersion of voyage speeds for the Mediterranean and New York–Brazil routes. From these curves the ratio of voyage speed dispersion to daily speed dispersion for different lengths of voyage is deduced. The author then goes on to consider the effects of fouling, draught, and form and speed, and these are studied in relation to the aforementioned curves. The curves represent average figures for coal-burning vessels with triple-expansion engines, one or two additional spots being plotted for other types of machinery, which indicate the improved time keeping of vessels with oil-fired boilers, and of the single motor ship for which comparative results were available. Finally, the effect of form of section is considered, and the author finds that the general trend of the results is in favour of the "U" type of section as compared with the "V" type. It is suggested that comparative figures derived in a similar manner would be useful, as a very large amount of data is necessary in order that safe conclusions may be drawn from the analysis made.

Professor P. A. Hillhouse, opening the discussion, said that the naval architect was always more interested in what the vessel he had designed would do in actual service rather than on trial trips. What affected the balance sheet was the speed on service, and that was a very difficult problem indeed to determine beforehand. Mr. Taylor had tackled it in a new way, and the method outlined should be exceedingly useful in enabling the naval architect to arrive at a more or less correct percentage to be added to the smooth water conditions to allow for conditions in service.

Dr. E. V. Telfer said that it seemed to him the difficulty could have been got over by using precisely the same analysis not in terms of speed, but in terms of apparent slip, because that was practically the guide to the power and speed absorption qualities of a particular ship. In getting out frequency curves, his practice was to arrive at the net percentage of time that applied to different weather conditions, and in that way he obtained a perfectly symmetrical curve for fine weather, another for moderate weather with a little overlap, and then another for heavy weather. The result was a diagram which was more or less symmetrical.

Mr. Lockwood Taylor, replying to Professor Hillhouse, said that although the paper referred to power margin, he preferred to work in terms of loss of speed which was what power margin came to. The skewness of the frequency curves obtained, mentioned by Dr. Telfer, might be due entirely to the weather, although fouling and other factors came into the problem and affected the curve. At the same time, he did not think that should have an important influence on the shape which was a function of the weather conditions. The vessels considered were all cargo vessels running at practically constant power and consumption.

B.E.S.A. SPECIFICATIONS.

PIPE FLANGES.

THE British Engineering Standards Association has recently issued Part 1 of the revised Tables of Pipe Flanges, Publication No. 10, which, with Part 2 (Steam), published in 1926, completes the revision of the 1904 edition. Part 1 comprises the three tables A, B and C, which deal with flanges for pipes, valves and fittings for gas and water. Dimensions are specified for pipes up to 72in. nominal bore for working water pressures up to 50 lb., and up to 48in. nominal bore for working water pressures up to 130 lb. and 175 lb. per square inch, respectively, the gas flanges are for working pressures up to 30 lb. per square inch.

Copies of the tables (No. 10, Part 1–1928) may be obtained from the Publications Department, British Engineering Standards Association, 28, Victoria-street, London, S.W. 1, price 2s. 2d. post free.

BY a majority, the Irish Railway Wages Board has rejected the railway companies' proposals that enginemen's and cleaners' wages be reduced by 1s. per week.

Report on a Three-Phase Turbo-Alternator.

By Professor S. PARKER SMITH, D.Sc.

No. II. (*Conclusion*).*

Stray Fluxes Round Overhang.

In order to measure the fluxes round the overhang, three sets of exploring coils were used. The first set consisted of three coils at right angles to each other, arranged to measure the axial, radial and tangential components of the stray flux in the space between the overhang and the end plate. A similar set of coils was arranged to measure the flux in the space between the overhang and the end shield. A third set of two coils was used for measuring the axial and radial components of the field between the straight part of the overhang and the end cover of the rotor winding.

To determine the phase relation of the stray flux, a cinematograph film was taken on the oscillograph. From the measurements taken this way, it was possible to map out the fluxes associated with the overhang. When the full load current reached its amplitude, the field round the overhang was found to reach a value of about 1000 lines per square centimetre, and this remained fairly constant in magnitude and direction from the rotor end cover up to the point where the bend in the overhang was completed. The direction of the field in this part was practically axial. The field decreased beyond the bend of the overhang until its sign was reversed. A knowledge of the direction and magnitude of these stray fluxes is valuable to the designer, for it enables him to determine in what direction the copper of the overhang should be laminated.

With regard to the leakage fields between the overhang and the end cover of the rotor, it was found that practically no stray flux entered the end cover within the overhang of the rotor winding. Up to this point the direction of the stray flux was practically axial; in the short distance beyond the rotor overhang flux entered the end cover. Here, again, the maximum values of the stray flux in this region was in the order of 1000 lines per square centimetre. This result was also interesting as it showed that practically no stray flux from the stator winding enters the end cover of the rotor winding.

Local Heating and Local Losses.

In order to measure the temperature rise and the loss at different points in the machine, the thermo-couples were employed as follows:—To determine the temperature rise, the machine was run under the required conditions until steady readings were obtained. It was then a comparatively simple matter to balance each thermo-couple on the potentiometer and so obtain its corresponding temperature rise. To find the loss at any given point, readings were taken at short intervals during the first one or two minutes after the excitation had been switched on; that is to say, before any of the heat generated at that place had time to dissipate itself into the surrounding parts. Assuming no heat to be conducted away in this initial period, we can write:—

Heat produced in joules = 4·189 × specific heat × weight in gm. × temp. rise in deg. Cent.,

or loss in watts = 4·189 × spec. heat × weight in gm. × temp. rise in deg. Cent. per sec.,

or loss in watts per kg. = 4189 × spec. heat × temp. rise in deg. Cent. per sec.,

where 4·189 = Joule's equivalent.

To find the specific heat of a composite body like copper embedded in mica a known loss with direct current was produced in the winding and the initial temperature rise was observed. In determining the initial temperature rise the readings taken during the first two minutes were plotted as a function of time and a tangent was drawn through the origin, whence the initial rate of temperature rise in deg. Cent. per second was obtained. In this way the following values were determined:—

Spec. heat of copper in slot = 0·1113 (theoretical value = 0·094)
" " overhang = 0·132 (" " = 0·094)
" iron laminations = 0·155 (" " = 0·11)

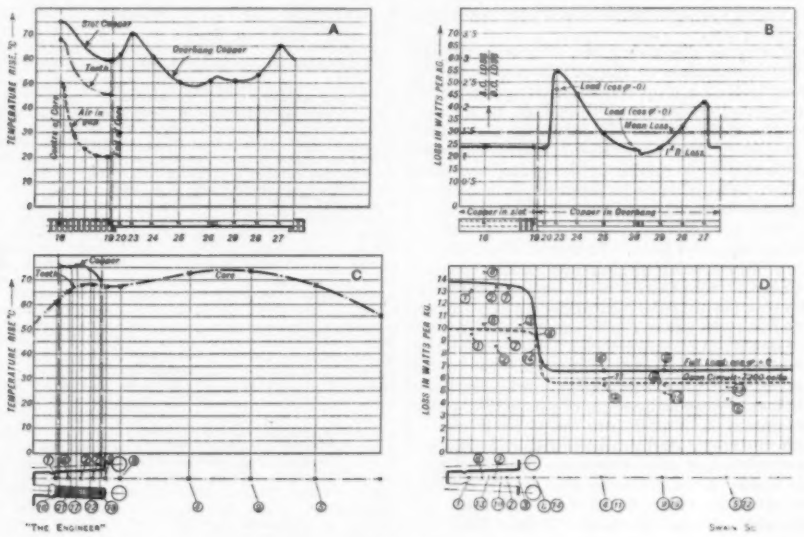


Fig. 7

A. Temperature Rise in Axial Direction on 23,400 kVA, 6600 v., cos φ = 0.
B. Loss in Stator Copper and Loss Ratio in Axial Direction on Short Circuit with Rated Current.
C. Temperature Rise in Radial Direction on 23,400 kVA, 6600 v., cos φ = 0.
D. Loss in Stator Iron in Radial Direction.

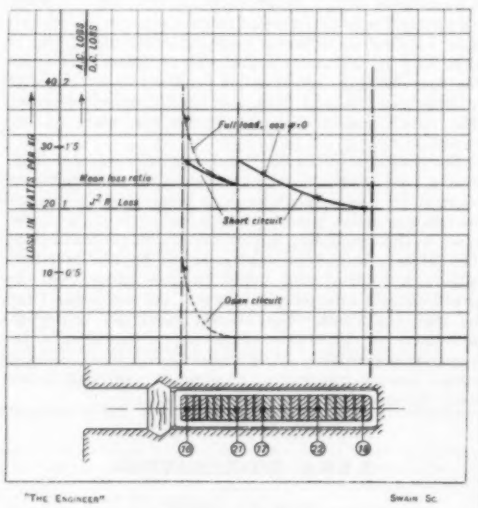


Fig. 8—Loss in Stator Slot Copper & Loss Ratio

* No. I. appeared April 6th.

Measurements in Axial Direction.—In Fig. 7 A are shown the temperature rises of the copper in the slot and overhang, of the iron in the teeth, and of the air entering the ducts when the machine was run at rated kVA and voltage at zero power factor. At this power factor the heating is greater than at the rated power factor of 0·8, owing to the high excitation loss—139·5 kW, against 96·3 kW. This causes the temperature rise at the core centre, where most of the rotor air is ejected, to be 13–14 deg. Cent. too high and at the core ends 3–4 deg. Cent. too high. Nevertheless the curves are a good guide to the actual conditions. It will be seen that the copper reaches its highest temperature rise, 75 deg. Cent., at the centre of the machine. Even at zero power factor this leaves a safe margin on the limit of 85 deg. Cent. allowed by the B.E.S.A. (Report No. 225). The iron and air curves follow a similar shape, the temperature falling towards the ends of the core. The copper temperature rises rapidly after the straight part of the overhang and then falls again towards the centre.

The sudden rise in the copper temperature just beyond the straight part of the overhang is explained by the curve in Fig. 7 B, which represents the loss per kilogramme measured on short-circuit with full-load current flowing. The two check points at cos φ = 0 show that the loss in the overhang is the same on short circuit as on load, with the same current flowing. The I²R or direct-current loss in the stator copper at 2050 ampères is 20 watts per kilogramme. In the overhang the copper loss rises to over 2·5 times this value with direct current. This is due to the action of the stray flux of the overhang, which produces its maximum effect at this point. Compared with the 25 per cent. increase in loss in the slot copper, this increase of 150 per cent. at one point in the overhang appears to be high, especially in a design where the copper is so carefully laminated. The discovery of its existence, however, amply justifies such extensive tests and the abundant cooling provided. Taken over the whole winding the loss ratio

$$\frac{\text{Loss with alternating current}}{\text{Loss with direct current}} = 1{\cdot}49,$$

that is, an increase of about 50 per cent. over the I² R loss.

Measurements in Radial Direction.—In Fig. 7 C the curves show the temperature in the stator iron and the slot copper radially at the middle of the core, with the machine running at its rated kVA and voltage at cos φ = 0. The general shape of these curves for the end packet is similar, but the temperatures are lower at the ends of the core. On full load it is seen that heat flows from copper to iron and not conversely. At cos φ = 0·8 the temperatures at the centre will be about 13 deg. lower than at cos φ = 0. The loss per kilogramme in different parts of the stator iron is shown in Fig. 7 D for the full-load condition at cos φ = 0, where the total iron loss is 177 kW. The density in the teeth is about 17,000 lines per square centimetre, and in the core about 13,000 lines per square centimetre. The dotted curve represents the iron loss with the same flux on open circuit. It is interesting to compare the average values of the measured iron losses on load with those measured on open circuit at the same induced E.M.F. (7200 volts).

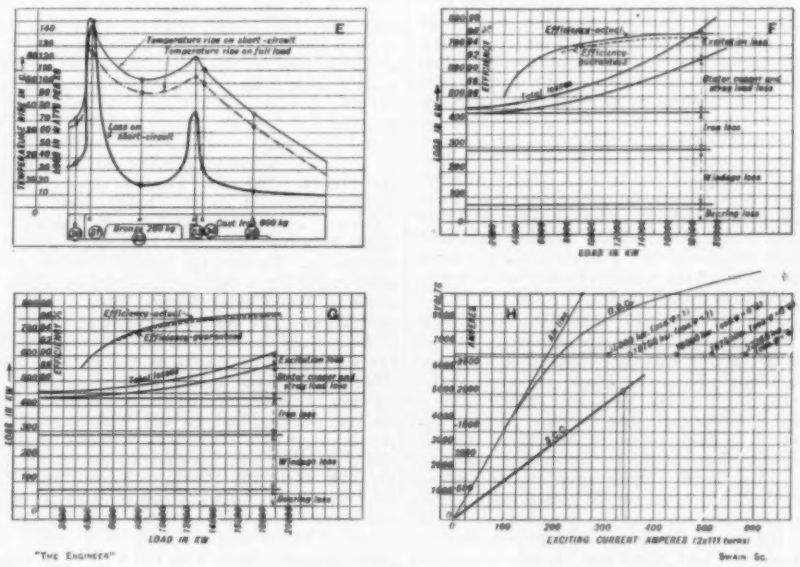


Fig. 9

E. Temperature Rise and Loss in Stator End Plates.
F. Losses and Efficiencies at cos φ = 0.8.
G. Losses and Efficiencies at cos φ = 1.0.
H. Open and Short Circuit Characteristics.

	Average loss per kg.	
	Core.	Teeth.
Rated kVA at cos φ = 0	6·6	13·6
Open-circuit at 7200 volts	5·65	9·9

It is seen that the iron losses on load are greater

than on no load with the same value of main flux. This is particularly the case in the teeth, and is probably due to the larger flux harmonics and oscillations which occur when the machine is loaded.

Of special interest are the curves in Fig. 8, in which the loss in the copper at the middle of the stator is shown. This loss was measured on open circuit at 7300 volts, on short circuit with full-load current, and on full load at cos $\varphi = 0$. The loss with direct current was also measured. The copper loss on open circuit is due to eddy currents set up by the main flux entering the sides of the teeth. This is only observable in the top two layers and emphasises the advantage of an empty space in the slot above the winding. The short-circuit test shows the loss produced in the copper by its own field, as usually calculated by Field's method. Starting at the bottom of the slot, it will be noticed that the loss ratio (alternating current loss/direct current loss) goes on increasing to 1·4, when it suddenly drops to 1·2. This is where the change occurs from three to four parallel strips per layer. Finally it reaches 1·4 again at the top layer. On load the open and short-circuit effects combine and the loss ratio reached 1·8. The average for the slot is 1·25. For the whole winding this ratio was found to be 1·49.

Heating and Losses in End Plates.—In order to reduce the loss in this inactive material the inside part of the end ring was made non-magnetic (bronze), cast iron being used for the outer part. The temperature and loss are shown in Fig. 9 E. The heating tests were taken on short circuit and on load, and it is seen that with the machine saturated on load the heating in the end plates is appreciably less than on short circuit, despite the core loss on load. The curves show the importance of adopting special means for reducing this source of loss. The loss curve was measured with the machine run under short-circuit conditions. It will be noticed how large the losses are in the thick part of the inside of the bronze plate, and that the temperature curves have the same peaks as the loss curve. From this test the loss in the two end plates was found to be 38 kW on short circuit, equivalent to about 34 kW on load.

Determination of Efficiencies.

The efficiencies were found by the "Summation of Losses" method, in accordance with B.E.S.A. report No. 225. This entailed a separate determination of each loss.

Windage Loss.—This was determined from air measurements by running the machine at normal speed unexcited. The windage loss was found to be 220 kW.

Stator Copper and Stray Load Losses.—By means of large air core choking coils, the machine was loaded to give its rated kilovolt-ampères and voltage at zero power factor. By deducting the known excitation and windage losses from the total loss thus measured, the sum of the iron, stator copper and stray load losses was obtained. This was found to be 377·2 kW.

In order to separate these losses, it is necessary to know the iron loss at the rated output of 23,400 kVA, 6600 volts at cos $\varphi = 0$. For this purpose a single loop was wound round the core and an oscillogram of the E.M.F. induced in it with the machine thus loaded was taken. The E.M.F. curve thus obtained represents flux to another scale; in other words, we have a curve of the distribution of the main flux in the air gap. This oscillogram is shown in Fig. 10 A, together with a direct voltage $E_f = 105$ volts, taken to calibrate the instrument. From this data the mean induced E.M.F., to which value the total flux is proportional, was found, whence the corresponding value of the E.M.F. induced in the winding with the machine thus loaded was calculated. This gave an induced E.M.F. of 7200 volts at 23,400 kVA, 6600 v., cos $\varphi = 0$. From previous measurements the iron loss at 7200 volts was known to be 177 kW, whence it follows that the stator copper plus stray load losses are 377·2 − 177 = 200·2 kW. Since the stator I^2R loss = 62·2 kW, it is seen that the stray load losses are 200·2 − 62·2 = 138 kW, or about twice the ohmic copper loss—a low figure for a large turbo-alternator.

It is interesting to compare the stray load losses under load conditions with the stray load losses on short circuit, full-load current flowing in each case. On load the stray load loss was found to be 138 kW, while on short circuit this loss—determined in the same way—was 181·2 kW. The higher value on short circuit is to be expected, because the stray fluxes can produce larger eddy currents in the iron when unsaturated.

The difference between the above figures indicates the discrepancy introduced by accepting the short circuit reading for the stray load loss, and illustrates the advantage of testing the machine at its rated kilovolt-ampères.

Iron Loss.—From the test data available, the induced E.M.F. at full load with a power factor of 0·8 was found to be 7000 volts. The iron loss corresponding to this voltage was 165 kW.

Rotor Excitation Loss.—From the measured characteristics, the excitation loss in the rotor at full load, cos $\varphi = 0·8$, was found to be 96·3 kW.

Bearing Loss.—This was determined from the quantity of oil and its temperature rise. For the two bearings it was found to be 68 kW.

In a similar way the losses at other loads at cos $\varphi = 0·8$ and at cos $\varphi = 1·0$ were found. The results are given in Figs. 9 F and 9 G, together with the efficiencies obtained therefrom. It will be seen that at both power factors there is a safe margin between the actual and the guaranteed efficiencies.

The losses at 18,750 kW, 6600 volts, at both unity and 0·8 power factor are tabulated below:—

Measured loss.	Loss in kW at—	
	cos $\phi = 0·8$.	cos $\phi = 1·0$.
Iron loss	165	148
Stator copper and stray-load losses	200	128
Rotor excitation loss	96·3	38·5
Friction and windage losses	288	288
Exciter and slip-ring losses	14·1	10·6
	763·4	613·1
Output in kW	18,750	18,750
Input in kW	19,513·4	19,363·1
Full-load efficiency in per cent.—		
Actual	96·09	96·83
Guaranteed	95·3	96·5

Characteristics and Oscillograms.

In Fig. 9 H the open and short-circuit characteristics of the alternator are given. From these curves the exciting current and regulation under different load conditions have been obtained. A few values are tabulated below:—

	Exciting current.	Voltage regulation in per cent.
	Ampères.	
Open circuit, 6600 volts	210	—
Short circuit, 2050 ampères	337	—
18,750 kW, cos $\phi = 1$	350	28
23,400 kVA, cos $\phi = 0·8$	515	43
23,400 kVA, cos $\phi = 0$	580	49

The steady short-circuit current with open-circuit excitation is thus 62 per cent. of the full-load current, and with full-load excitation at cos $\varphi = 0·8$ is 152 per cent. of the full-load current. These low values make for safe working, while the coarse regulation is no disadvantage at the present day, when automatic voltage regulation is universal.

The sudden short-circuit current was also deduced from the characteristic curves. Of the 337 exciting ampères required to send the full-load current through the stator winding on short circuit, 305 ampères were needed to overcome armature reaction, leaving 32 ampères for inducing an E.M.F. to counterbalance the effects of the several stray fluxes in the machine. The E.M.F. corresponding to this exciting current was 1150 volts or 17·5 per cent. of the rated voltage. At the instant of sudden short circuit, therefore, the stator current could rise to 100/17·5 = 5·7 times its full-load value.

A sudden short-circuit test was made, the exciter being used to bring the machine up to its rated speed. The machine withstood the shock without damage of any kind.

Oscillograms of the voltage curves are shown in Fig. 10 B for open circuit at 7300 volts, and in Fig. 10 C for rated kVA and voltage at cos $\varphi = 0$. The curves marked E_{ph} represent the voltage of one phase—that is, between a terminal and neutral—while the curves marked E_r represent the interlinked voltage—that is, between two terminals. The curves are seen to be practically pure sine waves.

Rapid De-magnetisation of the Alternator.

In the case of an accident, such as a short circuit in or near the alternator, it is important to reduce to zero the electromotive force induced in the stator winding as rapidly as possible, to prevent more serious trouble due to the consequences of overheating. For this purpose it is not sufficient to interrupt the magnetising current of the exciter. This is made clear in the oscillogram of Fig. 11 A, taken when the exciter field was broken with the alternator giving its rated kVA and voltage at zero power factor. The length of the oscillogram corresponds to 15 seconds. Although the exciter voltage e_x rapidly vanishes, it is seen that the exciting current i_x of the alternator and the induced E.M.F. E_r at the stator terminals die away very slowly. This is due to the time taken for the main field to decay. Even after 15 seconds remanent magnetism in the exciter causes a fairly large E.M.F. to be induced in the alternator. This method of reducing the main flux to zero is too slow to prevent trouble spreading. The objection to breaking the rotor current is the possibility of a large E.M.F. being induced in the rotor circuit in the case of a sudden short circuit.

The method employed with the present alternator is a new one that has been developed by the Oerlikon Company.

The effect of this method is to cause the main field current to vanish very rapidly without the danger of large electromotive forces being induced in the rotor. The rapidity with which the exciting current and the alternator electromotive force reach zero is shown in Fig. 11 B, taken under the same conditions as the oscillogram in Fig. 11 A. The de-magnetising switch is arranged to operate before the main switch, so that in the event of an external short circuit, the latter has only to clear a small power and can therefore be correspondingly rated. With this system there is

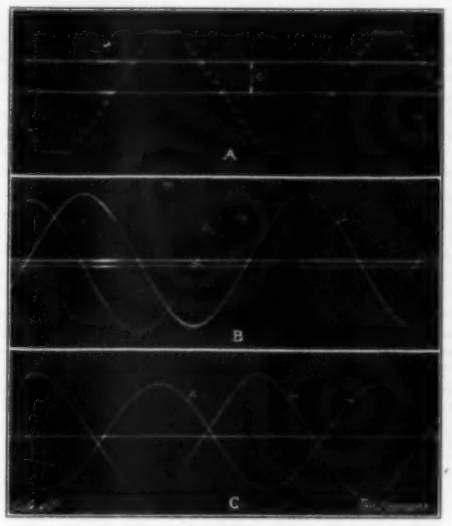


Fig. 10

A. Flux Distribution at 23,400 kVA, 6600 v., cos $\varphi = 0$.
B. Phase and Interlinked Voltage on Open Circuit, 7300 v.
C. Phase and Interlinked Voltage at 23,400 kVA, 6600 v., cos $\varphi = 0$.

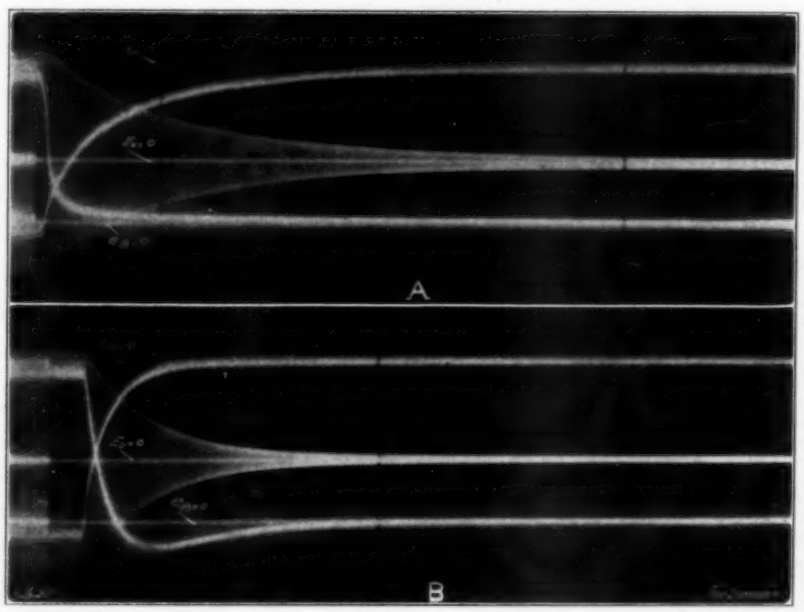


Fig. 11—Conditions on Sudden Short Circuit

(A) Without, and (B) with Rapid De-magnetising Devices

also no danger of self-excitation and stationary oscillating currents. The theory on which this method is based would take us beyond the limits of the present report, and may be left for a future publication.

Conclusion.

From a close study of this machine, two facts emerge. First, that great importance has been attached throughout to reliability; secondly, that the total improvement has been gained by attention to details. By taking pains wherever possible to reduce losses and ensure uniform cooling, the designer has been able to use his material economically, while the adequate attention that has been paid to sound construction shows that these advantages have been gained without sacrificing reliability.

The thorough tests to which the machine has been subjected not only serve to confirm the soundness of the design, but they afford valuable information regarding the performance of machines of this class.

Obituary.

WILLIAM WILLOX.

We have to record, with regret, the death on April 7th of Mr. William Willox, for fifteen years the chief engineer of the Metropolitan Railway, from which position he retired in June, 1921. He gained considerable experience in railway construction as a contractors' engineer, mostly abroad, and became connected with the London, Brighton and South Coast Railway some thirty years ago, when he was made resident engineer for the Stoat's Nest and Earlswood duplication. Soon after the completion of that work he was appointed engineer for the northern division, and held that position until his appointment to the Metropolitan. Mr. Willox joined the latter company when the conversion from steam operation to electric traction had just been begun, and thus found ample scope for his great abilities. One of his first new works was the enlargement of Baker-street Station, which necessitated the opening out of a length of the tunnel under Park-place and the provision of an ordinary double junction in the Circle lines, instead of a trailing connection, which permitted, from July 1st, 1909, the passage of through trains between the City and the Harrow line. The whole equipment of points and crossings in the yard at Baker-street was relaid in manganese steel. In 1911 King's Cross Station was rebuilt, and included in that work was the construction of a new over-bridge in reinforced concrete to give direct access between Caledonian-road and Grays Inn-road. The bridge crosses four lines of way on the skew and is 130ft. long on the square, and was the longest reinforced concrete bridge at that time in London. The widening between Finchley-road and Harrow followed, and was completed in 1915. It included the construction of a fine hog-back lattice-girder skew bridge, 147ft. long on the square, over the Kilburn High-road. When, as a sequel to the electrification, automatic signalling had to be installed, Mr. Willox set up a new departure for this country by having the signals operated electrically, instead of, as on the District and the Tube Railways, on the electro-pneumatic system. Three signal-boxes were equipped for power working of the points and signals and electricity was solely used. The Metropolitan, under Mr. Willox, was, in 1909, the first British railway to move the signal arm from the normal to the "clear" position through the upper quadrant, *i.e.*, to raise it, and not to lower it, from the horizontal. Fog repeaters, again, were introduced in 1912. Fogmen were thereby dispensed with and better indications in fog were given to drivers. Mention must also be made of the successful experiments made in Clerkenwell Tunnel to give audible warning of the approach of trains, by mechanical means, to men working in smoky tunnels. Mr. Willox was a member of the Institution of Civil Engineers, to which body he contributed, on February 14th, 1914, an interesting paper, "Rails for Electric Railways," and on March 21st, 1922, one on "Automatic Signalling on the Metropolitan Railway."

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

TESTS ON A THREE-CYLINDER COMPOUND LOCOMOTIVE.

Sir,—As a foreign member of the Institution I could not be present at any of the discussions on Mr. Lawford H. Fry's recent paper on "Some Experimental Results from a Three-cylinder Compound Locomotive," which indeed I have only just read in the last issue of the "Proceedings." I trust therefore that you will allow me to refer to one or two points in the paper.

In the first place the method of distorting the indicator cards of a compound engine in order to eliminate the effects of clearance steam is well known, being fully described in "The Steam Engine," by Ewing. The cards so distorted are unchanged in area by the process, and therefore represent the work done in the cylinders as truly as before. The object of the distortion is to enable the cards in their new form to be compared with the area under an adiabatic curve representing the expansion of the steam fed to the H.P. cylinder. So far, therefore, Mr. Fry is following known principles, but when he closes the adiabatic curve in the way he does, and takes the area so contained as representing the work which should theoretically be performed by the steam used per stroke, he not only sets up a different standard for every engine, but obtains an "efficiency" which has no relationship with the thermodynamic merits of the machine.

The criticism which Mr. Fry's proposed "locomotive cycle" received at the hands of various speakers makes it unnecessary for me to refer to it further. The question which I would particularly like to raise is with regard to the distorted diagrams given in Fig. 8 of the paper. Nine combined cards are shown surrounded by ideal diagrams corresponding to the respective "locomotive cycles." In no less than four cases the cards are shown projecting beyond the adiabatic lines representing the ideal expansion of the working steam. I suggest that such conditions are impossible if the cards are correct and are correctly manipulated. Instead of the usual "missing steam" between the cards and the adiabatic we have some "excess steam," for which there is no accounting. Look at the diagram representing test No. 7906 for example. The expansion line of the H.P. card crosses the adiabatic at about 310 lb. and recrosses it at about 220 lb. Between these pressures therefore the area of the card is greater than the area bounded by the adiabatic between the same pressures. The only deduction possible from this fact is that the steam must have been doing more work than theoretically it could do, while it was expanding from 310 lb. to 220 lb. To draw conclusions as to cylinder efficiency from cards of this kind would seem of doubtful utility.

M.I. Mech. E.

April 10th.

OIL ENGINE PERFORMANCE ON COAL OIL.

Sir,—Many months ago I accepted the invitation to send to Mr. J. S. Brown, at the Royal Technical College, Glasgow, some 20 gallons of oil made from coal at the works of the Comac Oil Company, Ltd., Coalburn, Lanarkshire. The coal from which the oil was made consisted of a mixture of double and treble washed nuts obtained from six seams of bituminous coal worked by the adjacent Bankend Colliery Company, Ltd. I had no idea that any doubt existed of the nature of the raw material from which the oil was produced until I had received on the 3rd inst. a copy of The Engineer for March 23rd, 1928, and had read the letters published therein from Mr. Harald Nielsen and from Mr. Maclaurin.

I am obliged to Mr. Maclaurin for pointing out that the Turner oil is the crude oil as it comes from the separator and that the Nielsen oil is a refined product from the "L & N" crude oil from coal. The vapours coming from the Comac retort pass in series through four condensers. The condensate in the first condenser is a very thick oil at normal temperature and pressure. It is spoken of as wax, and amounts to one-third of the total yield of oil. The condensates from the other three condensers are mixed, and consist of condensed steam water and a thin dark red oil. It was this oil, amounting to two-thirds of the whole oil produced from the coal, which was delivered by me to Mr. Brown, without treatment of any kind.

I am interested to learn from Mr. Nielsen's letter that the tests of the coal oils arose out of a talk which he had with "the head of a famous firm of Diesel engine builders and a well-known consulting engineer." As the test showed the Nielsen oil to be inferior to the Turner oil, Mr. Nielsen's attitude is comprehensible, but it does not excuse his assertion that the Turner oil was made from cannel, nor does it entitle him to blame Mr. Brown for not questioning the fact of its production from bituminous coal. If Mr. Nielsen had acted on the advice he offers to Mr. Brown to communicate with me, he would have learnt that the Turner oil was produced from bituminous coal and not from cannel. In his own patent specification No. 287,037, lodged on September 22nd, 1927, he gives particulars of an oil similar to the Turner oil, which, he asserts, is produced from a bituminous coal having a volatile content of 30 per cent. This is not a matter of surprise to me, as the method adopted for its production is merely a variation of my own process.

Charles Turner.

Glasgow, W. 2, April 6th.

WAYLEAVES.

Sir,—The Overhead Lines Association has undertaken to compile data concerning suitable agreements, notices, terms, &c., for the guidance of the Electricity Commissioners. This matter is of very great importance, as a carefully agreed basis that is fair to all parties will greatly facilitate the distribution of electricity in rural areas. This Association was able to give much useful information to the Electricity Commissioners in connection with the revision of their overhead line regulations; also members of the Council were able to assist personally in the matter. The Association is anxious to keep up its reputation, and therefore would be glad to receive notes from all those who have had experience in dealing with wayleaves (kindly address same to our hon. secretary, Mr. Theodore Stevens, 50, Lincoln's Inn-fields, W.C. 2). Already, thanks to the initiative of our hon. secretary, we have been able to analyse a number of existing forms for the Commissioners in such a novel way as to show what a number of omissions occur even in the best of these forms.

Points that should be borne in mind are the following:—Acts subject to and rights reserved—landowners' obligations; notice before erecting buildings; moving of wires; indemnities—electricity suppliers' obligations; route; carrying out of works; making good; indemnities; local authorities' obligations. Notices; new works; to alter; to terminate agreements; to restore; to lop or fell. Payments; to landlords; to tenants for life; to leaseholders; to annual tenants; classes of poles; classes of land (arable, grass or pasture); underground cable; damage to crops during construction; rates and taxes. Arbitration of disputes. Publicity.

R. Borlase Matthews,
President, Overhead Lines Association.

London, April 10th.

SIXTY YEARS AGO.

With the replacement of wood by iron in the construction of warships the Government dockyards ceased to be, as they had been for centuries, the sole establishments entrusted with the building of naval vessels. The private shipbuilder came into prominence because the Navy clung to wood long after iron had become firmly established as a material for the construction of merchant vessels. When the dockyards, embedded in the traditions of wooden construction, turned their hands to iron they found their skill in that material far behind that possessed by the private yards, and to an increasing extent the private yards began to receive orders from the Admiralty for the construction of iron warships. It is true that at first the private yards, accustomed to tendering for mercantile vessels, misjudged the financial aspects of warship building and in many instances had to seek additional remuneration over and above their contract price. With the passage of time they, however, accumulated experience which led them to seek orders for the construction of warships, not only from our own Admiralty, but from foreign Governments. Simultaneously they acquired much knowledge concerning the designing of warships. During the American Civil War the private yards of Great Britain added greatly to their experience and their profits by the building of war vessels and blockade runners. While the Admiralty surrendered its exclusive duties in the matter of warship construction to the private yards with a fair amount of grace, it refused to hand over in any measure its privileges in the matter of design. Parliament stirred in the matter. It urged that to improve the standard of our fleet competitive designs should be invited from the private builders. In May, 1867, the Admiralty, more driven than willingly, addressed a circular letter to several shipbuilding firms to submit competitive designs for either a broadside or a turret ship. In response designs were received from the London Engineering Company, the Millwall Company, and Messrs. Palmer, Napier, Samuda and Laird. For some time nothing further was heard about the designs until Mr. Samuda, himself a member of Parliament, and as such precluded from accepting an order from the Admiralty, pressed for the publication of a report on them. That report, which became known as "Mr. Samuda's return," was duly published. It was found to have been compiled by Admiral Robinson, Controller of the Navy, and Mr. E. J. Reed, the Chief Constructor. The designs were one and all condemned in it. In our issue of April 10th, 1868, we opened a discussion of the subject. We expressed ourselves in terms which to-day would in similar circumstances probably involve us in several libel actions regarding the justice of a system which led to the designs being adjudicated upon by those who were in the position of being competitors of the firms submitting the designs and who, had they favoured any one of the designs or expressed approval of it, would thereby in effect pass a vote of censure on themselves as designers of warships.

ITALIAN 1000 MILES ROAD RACE.

One hundred cars took part in Italy's thousand miles road race, which was recently successfully run, by reason largely of perfect organisation and the use of troops to guard the whole of the highway. The race was won by Campari and Ramponi, driving a supercharged 1500 cc. Alfa Romeo, with which they covered the thousand miles in 19 hours 14 minutes 5½ seconds, thus maintaining an average speed of 52½ miles an hour, or 4 miles an hour faster than last year. A 2000 cc. O.M., driven by Mazzotti and Rosa, finished second, 8 minutes behind the winner; while a Lancia came in third in 19 hours 37 minutes 37⅗ seconds.

The competing cars were divided into five classes according to engine size, the smallest being limited to 1100 cc. In this division the 9 H.P. Fiat model was successful, the first place being won by a car driven by Gilera and Manenti, in 23 hours 59 minutes 5½ seconds, which gives an average speed of 42 miles an hour, followed by a second Fiat, then a S.A.M., a third Fiat and an Amilcar.

Starting at Brescia, the competitors ran through Bologna, crossed the Apennine Mountains to Florence, checked in at Rome, then again crossed the Apennines through Perugia to Ancona on the Adriatic. They then ran up to Bologna, passed through Ferrara and Treviso, and traversed the Venetian plains through Vicenza and Verona to the terminus point at Brescia. The race was a most severe test of both cars and men by reason of the mountainous region to be passed through, and the fact that a whole night had to be spent on the road. Although few of the roads were dustless, the race took place without a single accident of any kind.

Titanium oxide is interesting in that it has the greatest refractive index of any known white pigment, resulting in "hiding power" heretofore unattained.

Railway Matters.

IT is officially announced that Mr. H. S. Davies, chief assistant to the London district engineer, London and North-Eastern Railway, has been made Leeds district engineer in place of Mr. T. H. Seaton, whose removal to the Stratford district was noted in this column on March 2nd.

A QUESTION was asked in the House of Commons on March 22nd as to the circumstances under which rails to the value of £500,000 were presented to the Union of South Africa. Mr. Churchill said, in reply, that the material in question had been used in France, and that in 1919 it was decided to make the gift in recognition of services, of at least an equal value, rendered by the South African Government in the transport of troops and material during the African campaigns.

THE accident reports received from the New York Interborough Railway—which operates the subway system—show that 20,934 passengers were injured during last year, of whom 7060 were hurt in attempting to enter or leave trains. The New York correspondent of the *Manchester Guardian*, in giving this information, adds that as the automatic gates on the trains—which prevent the signal to start being given unless the doors are closed—are very nearly fool-proof, it is fair to suppose that a majority of these individuals sustained their injuries during the periods of bad overcrowding.

IT may be remembered that one incident of the general strike of May, 1926, was that a reduced minimum was placed on the weight of the parcels sent through the post. As the railway companies are paid a commuted sum for the carriage of parcels mails they had consequently, during the restricted period, less weight to carry. Taxpayers will be glad to know that that fact was not lost sight of by the Treasury, but that, according to the 1926–27 Appropriation Accounts, a reduction of £25,000 was made in the payments to the railway companies owing to a decrease in the average weight of parcels carried.

THE first paragraph in this column of our issue of January 27th stated that the first twenty-five engines of the "Royal Scot" class were to be named after famous regiments. It is now officially announced that the next twenty-five are to have the names of well-known locomotives of the early days of railways. They will be:—"Lancashire Witch," "Novelty," "Comet," "Planet," "Vulcan," "Samson," "Vesta," "Ajax," "Caledonian," "Mail," "Condor," "Courier," "Lady of the Lake," "Sanspareil," "Meteor," "Liverpool," "Phœnix," "Atlas," "Goliath," "Fury," "Hector," "Lion," "Ostrich," "Jenny Lind," "Velocipede."

SINCE the early days of railways there have been porters who have been qualified to act as signalmen and others to act as guards. But as there has been no vacancy for them to act fully as signalmen or as guards, or, possibly, because there was no opportunity for them to act as such for more than part of the day, they have been ranked as porter-signalmen or as porter-guards, and have been paid at a slightly higher rate than the ordinary porter. As we say, that has been the practice for the last sixty years at least. The National Union of Railwaymen has, however, objected to that being done, as it wants each man to have allotted duties given to him, and the case came recently before the National Railway Wages Board. The answer of the companies was that were the men's appeal granted, wages at signalmen's or guard's rates would have to be paid to such men when working as ordinary porters.

IN speaking at Southampton at the recent dinner of the docks and marine department staff, Sir Herbert Walker, the general manager of the Southern Railway, said that four years ago the Mayor of Southampton asked that the company should undertake four things—provide increased hotel accommodation; improve the Terminus Station; start on the docks extension; and build the new overbridge at the West Station, so as to dispense with the level crossing there. He was able to report that the first two of these undertakings were nearly completed, the third was well in hand, and they hoped to begin operations on the fourth item some time during the current year. On the subject of the marine department, Sir Herbert observed that last year the company's steamers carried 1,500,000 cross-Channel passengers and 2,000,000 in the Isle of Wight service without accident of any kind.

THE London and North-Eastern Railway Company has increased the amenities of its Harwich–Antwerp steamboat service by the installation of an electrical orchestra on the ss. "Bruges." The apparatus, supplied by the Gramophone Company, of Hayes, Middlesex, employs ordinary gramophone discs, but the sound is amplified by means of a thermionic valve and reproduced by a special loud-speaker consisting of an aluminium diaphragm 0·001in. thick and 30in. diameter concealed in a handsome cabinet on the companion-way landing. The reproduction is exceedingly good, and the volume of sound under perfect control. The introduction of the new orchestra was marked by a luncheon and concert on the vessel in Antwerp on March 31st, presided over by Mr. Tedder, assistant to the director of the London and North-Eastern Railway continental services, and Mr. L. H. K. Neil, the company's representative in Brussels.

THERE were twenty-eight inquiries into the more serious accidents to railway servants during the three months ended on June 30th last. Ten of the cases had fatal results, of which five were described as due to misadventure, two to want of care, one to a defective lift, and two to no look-out men being provided. An unusual feature of these ten fatal accidents was that three of them were to signal fitters, and in each instance there arose the question of their protection by look-out men; in two the cause of deaths was said to have been contributed to by there being no look-out man provided. Moreover, in one of the latter cases Mr. Scott Main said: "Generally, I am of opinion that there is need for more specific instructions with respect to the protection of men in this employment. The fact is also to be noted that had the services of a special look-out man been considered necessary by . . . which he now maintains was the case, he had not in his gang any man passed as competent to act in that capacity nor had he been provided with the necessary outfit with which to equip him."

Notes and Memoranda.

IT is claimed that the use of arc welding, in the place of riveting, in the construction of a building at the West Philadelphia plant of the General Electric Company resulted in a saving of from 12 to 15 per cent. of steel. The building has an area of 80,150 square feet and is 50ft. high.

IT is stated that the Mersey River, in Nova Scotia, is capable of providing at least 35,000 horse-power, and of this amount some 20,000 horse-power will be utilised by a newsprint mill which it is proposed to put up at Liverpool, N.S. The works will be the second largest in the province.

AN improved process for the recovery of radium from low-grade carnotite ores, which are now being mined and milled for their vanadium content only, is being devised by the American Bureau of Mines. This by-product radium is now discarded in the tailings. Many highly oxidised ores containing base and rare metals do not respond to the usual concentration methods. This is particularly true of the slime portion. The possibility of centrifugally concentrating these ores is being studied with favourable results to date.

A STUDY of the ignition of methane by heated surfaces is being conducted by the Electrical Section of the Bureau of Mines at the Pittsburgh Experiment Station in the hope that the knowledge gained by this research may throw considerable light on the causes of various mysterious mine explosions. Methane, a highly flammable mine gas, might, it is pointed out, be ignited by such agencies as an overheated mining machine bit, the friction spark from a sulphur ball, the sliding of rock down an iron chute, or the grinding of rock against rock.

ELECTRIC furnace cast iron is stronger, tougher, and more dense than cupola iron, according to the United States Bureau of Mines, and a higher recovery of metal in casting can be obtained as a result of the higher pouring temperature. Cast iron scrap of high-sulphur content can be converted into high-grade cast iron, low in sulphur, either by melting directly in the electric furnace or by refining molten metal from the cupola. Large additions of steel scrap may be used if desirable, or steel scrap can be used entirely and synthetic cast iron made.

IN a short article on catalysts for the production of sulphuric acid the *Chemical Trade Journal* mentions the growing vogue of vanadium in the place of platinum for the purpose. It is stated that the new catalyst consists of complex vanadium silicates used either as such or diluted with various inert substances of any particle size. In either case they exhibit an exceptionally high activity showing conversions of sulphur dioxide to sulphur trioxide of 97 to 98 per cent. and even above, which conversions are maintained at the usual commercial loading rate.

A NOTE in the *Iron and Coal Trades Review* as to the regulations in a Mexican mine suggests that they have been modelled on the lines of engineers of a generation ago, who always wore hard "bowler" hats to give them a warning against bumping their heads against obstructions. The note referred to says:—"Nobody—miner, manager, or visitor—is allowed to go underground at a certain Mexican copper mine recently visited by a United States Bureau of Mines engineer unless he is wearing a so-called 'hard-boiled' hat. The company furnishes these hats to the men for 50 cents (2s.) each and replaces damaged ones free of cost." The construction of a hard-boiled hat is not, however, explained.

SPEAKING on the weathering of brick before the recent Convention of the American Common Brick Manufacturers' Association, Mr. J. W. McBurney said that no evidence had been presented showing a relationship between water absorption and weathering. The only absolute test for weather resistance was 100 years' or more exposure. Repeated freezings and thawings conducted in the laboratory were the next best test. Brick of a relatively high absorption and of a high rate of absorption was desirable from several standpoints. The bond between brick and mortar was better with absorbent brick. On the basis of a limited field inspection, the chance of a dry wall was better with a porous absorbent brick than with vitrified brick.

THE drone of an aeroplane motor has, according to *Engineers and Engineering*, been utilised to throw a switch controlling floodlights at air ports. This latest engineering achievement is seen as an important aid to night flying and as a valuable economic contribution. Inability of landing field forces to gauge with any degree of exactness the arrival of night "sky riders" has heretofore necessitated almost continuous operation of full complements of flood lamps until a safe descent has been made. Recent experimentation of the device at a Pennsylvania aviation field has demonstrated that the hum of an aeroplane motor 1000ft. away can close a switch which lights banks of lamps on the field. A "loud speaker" operated reversely is the "ear" of the mechanism by which the drone of the plane controls electrical energy. The impulse passes several amplifiers to a time-limit relay which is the final step before the current throws the switch.

SOME investigations carried out by Messrs. W. K. Lewis and P. K. Frohlich at the Massachusetts Institute of Technology, and described in *Industrial and Engineering Chemistry*, has shown that methyl alcohol of high purity may readily be prepared by passing a mixture of carbon monoxide and hydrogen, preferably at a pressure of several hundred atmospheres and at temperatures between 300 deg. and 350 deg. Cent., over a catalyst composed of metallic oxides. With a catalyst of medium activity prepared from the oxides of copper, zinc, and aluminium, it is possible to reach nearly theoretical conversion depending upon the pressure, temperature, and rate of gas flow employed. The catalyst, consisting of the oxides of copper, zinc and aluminium supported on metallic copper, appears to be most active at lower temperatures and suffers a permanent decrease in activity when exposed to higher temperatures. Also the catalyst is sensitive to poisons. By connecting several chambers in series, however, it is possible to dispose of the catalyst poison in the first chamber, thus protecting the contact material contained in subsequent reactors.

Miscellanea.

THE new bridge over the Thames between Windsor and Datchet was formally opened by Sir Wm. Mount on the 5th inst.

IT is officially announced that the new French cruiser "Tourville," of 10,000 tons, attained a speed of 36·07 knots during her trials in the Bay of Biscay.

OF the four vessels now on the stocks at the Maisonneuvre yard of the Canadian Vickers Company, near Montreal, one is a motor ship, which is to be launched in May.

THE latest official estimate of the output of minerals from Canada for 1927 shows a value of 244,520,098 dollars, which represents an increase of over 4,000,000 dollars during the twelve months.

THE Kwantung Government has decided to construct a large reservoir with a volume of 15,000,000 tons of water between Dairen and Port Arthur, at the cost of £555,700. Work is expected to be finished in five years.

A PRELIMINARY trial of the new coal staithes at Blyth, which are to be officially opened on April 16th, has just taken place. The staithes have cost £300,000, and will be capable of handling a million tons of coal a year.

THE Port of London Authority has announced that a substantial reduction in the rates on exports shipped over the Authority's dock quays will take effect from May 1st. The revised schedule will be published very soon.

THE extension of the synthetic ammonia works at Billingham-on-Tees will involve the supply of 45,000 tons of structural steel by Dorman, Long and Co., Ltd., and 2200 tons of steel, for the new boiler-house by Redpath, Brown and Co.

TOWARDS the end of February the power station at Yallourn, Australia, achieved a record with an output of 61,000 kilowatts. The normal rating of the plant is 50,000 kilowatts, but it is being extended by the addition of another 12,500-kW set.

THE first two completed submarines of the Jugoslav Fleet have arrived at the port of Attaro. The two submarines were laid down by Armstrong, Whitworth and Co. in 1926. They carry two 4in. anti-aircraft guns and six 21in. torpedo tubes.

SPEAKING at the annual meeting of the Petroleum Technologists recently, Mr. A. Wade said that he did not consider that the production of petroleum by drilling in Derbyshire was a commercial proposition. The average yield from the well at Hardstoft was, he said, about six barrels a day.

THE total nitrogen consumption of the world now exceeds 1½ million tons per annum, and is increasing at the rate of approximately 50,000 tons of nitrogen per year. In a short time there will, it is said, be used in the world 2,000,000 tons a year of combined nitrogen, which is equivalent to 10,000,000 tons a year of ammonium sulphate.

THE Kwantung Government has definitely decided to establish a soda ash factory in Manchuria. The company will be placed under private management with an initial subsidy of about £150,000 and annual subsidies for several years. The demand for soda ash in Japan proper is 140,000 tons per year and the cost of production is approximately £8 per ton. The Kwantung production cost is about 12s. per ton less than that of Japan.

THE plant which has recently been installed at Trail, British Columbia, for the electrolytic production of cadmium, is turning out from 500 lb. to 600 lb. of that metal daily. The cadmium is obtained from the zinc ores and is recovered from the electrolyte by agitating it with atomised zinc. This precipitates the cadmium and copper and small quantities of other metals. This residue has been saved since the start of the electrolytic zinc plant, and a large amount of it has been accumulated.

AN International Peat Congress is to be held in Laon and Notre-Dame-de-Liesse, in France, from July 8th to 12th, under the auspices of the Office National des Combustibles Liquides, 85, Boulevard Montparnasse, Paris 6. In connection with the Congress at which papers dealing with the peat industry are to be read and discussed, an Exhibition is to be held which is to open on July 8th and close on July 15th. Notices as to exhibits are to reach the secretary at the Office National before May 1st.

THIS year's annual endurance motor vehicle test of 472 miles from Tunis to Tripoli was marked by such extraordinary weather during the first day's run, from Tunis to Gabes, that the committee had to postpone the departure of the second stage for twenty-four hours. A storm, which burst soon after the start, was of such violence that the roads were completely flooded at the frontier region between Ben Gardena and Pisida, and large numbers of the competitors were unable to reach their destination.

ARRANGEMENTS were completed, at a Conference, held recently at Cortino d'Ampezzo, for a considerably extended service of motor coaches next summer in the Italian Alps, with extensions into Switzerland and France. There is hardly a road in the Alps which is not now covered by motor coach services, some of these vehicles crossing at altitudes of more than 9000ft. Under the recent agreement, the coach services will not stop at the frontier line, but will be continued into the adjoining country, thus giving an opportunity for international travel hitherto unknown. Among these important services is one from July to September around Mont Blanc, from Chamonix over the Grand and the Petit St. Bernard to Courmayeur, and *vice versâ*. There will be two services, one by a French and the other by an Italian company, using 11-passenger Fiat and Spa coaches. Another international service is one from Turin in Italy over the Alps to Briançon in France, thus uniting two towns which are only indirectly connected by rail. The height of the pass on this route is 6669ft. Spa 20-passenger coaches are used for this run. There is another direct daily service from Turin to Nice, *viâ* the Col de Tende, at an altitude of 3248ft. Mont Cenis, 6836ft. above sea level, can be reached daily by Spa motor coaches starting from Turin, and from the top of the pass French coaches carry travellers to Modane and Chambéry.

CALCUTTA WATERWORKS—NEW PUMPING STATION AT PULTA

MESSRS. ST. GEORGE MOORE AND LA TROBE BATEMAN, M.M. INST. C.E., WESTMINSTER, ENGINEERS

(*For description see page* 394)

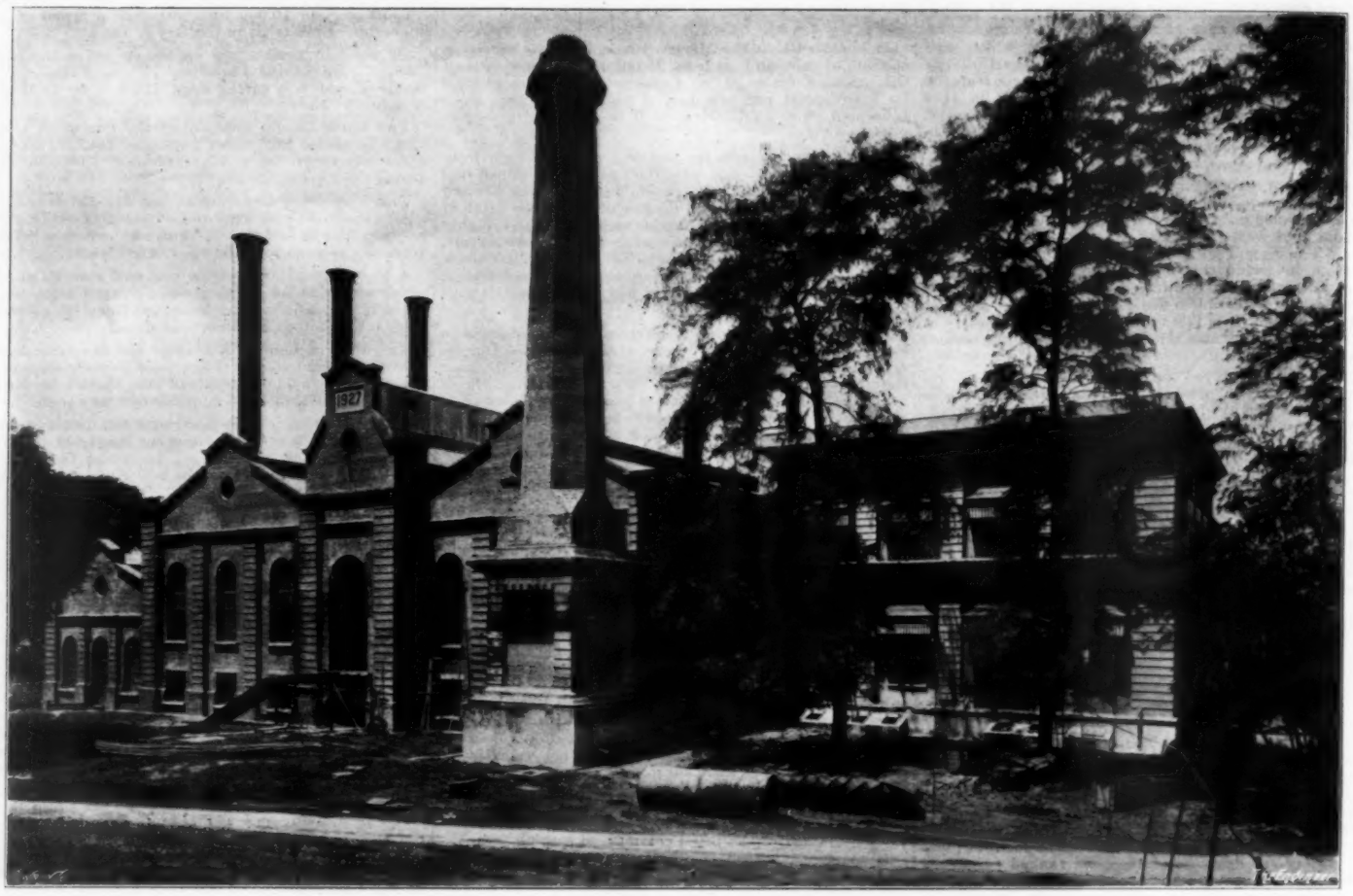


FIG. 6—SOUTH ELEVATION OF NEW STATION, WITH OLD STATION ON THE RIGHT

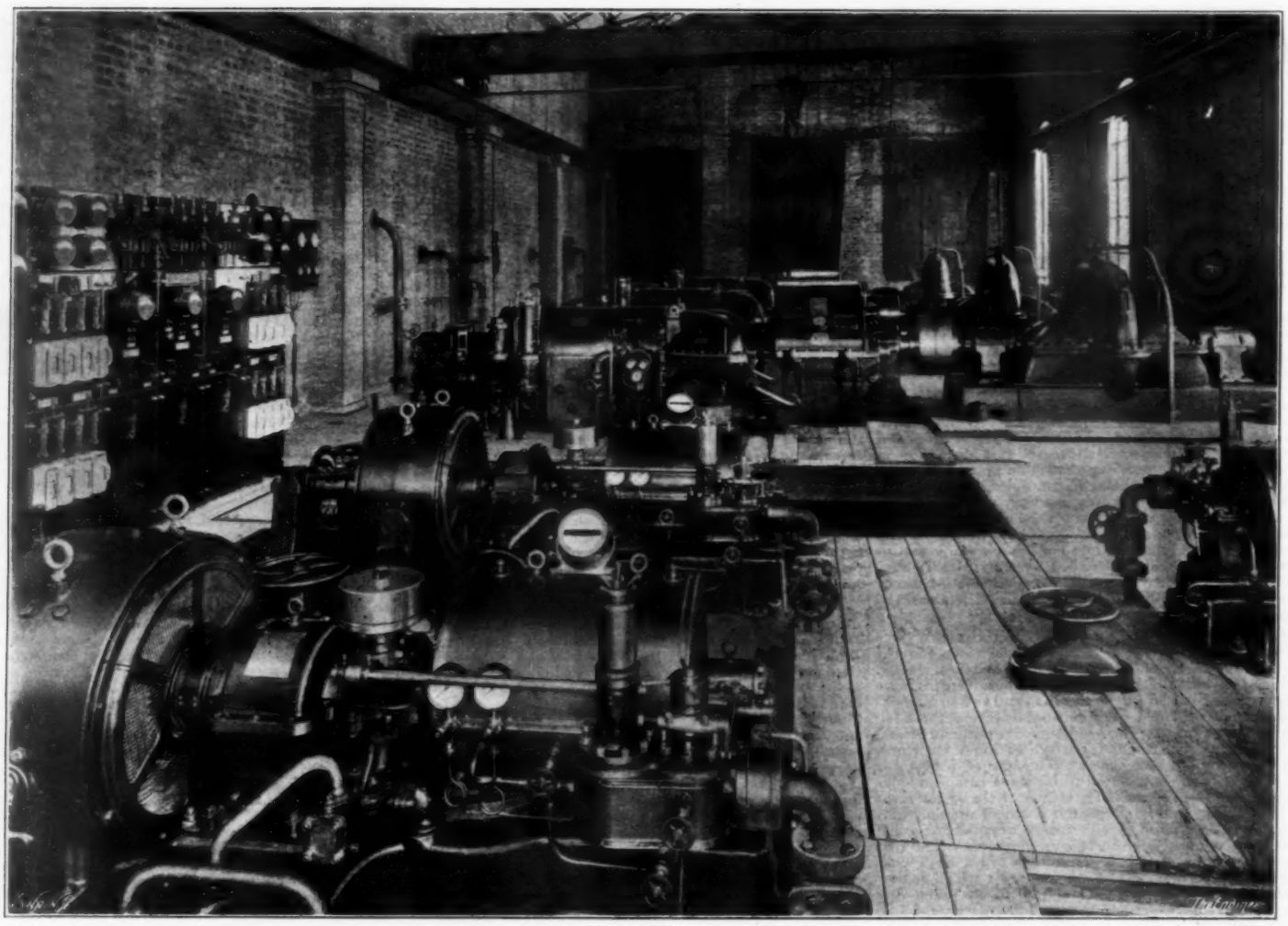


FIG. 7—INTERIOR OF NEW STATION, SHOWING PUMPS, TURBINES AND GENERATING SETS

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DEATH.

ON Easter Morning, 1928, at "Colombo," Firgrove Hill, Farnham, HENRY THOMAS SIMPSON WARD, M. Inst. C.E., late Director of Irrigation, Ceylon, in his seventy-ninth year.

THE ENGINEER.

APRIL 13, 1928.

Smaller Battleships in Prospect.

AMERICAN newspapers received during the past week contain a great deal of matter relative to the British proposals for a reduction in the size and armament of future capital ships. This plan, which was first submitted at the abortive Naval Conference at Geneva last summer and has now been reintroduced to the Preparatory Commission on Disarmament, presupposes a genuine desire on the part of all the leading naval Powers to retrench their expenditure on naval armaments so far as may be compatible with security. We believe this desire does exist among the statesmen and the peoples of each nation concerned, in spite of the obstructive attitude of certain groups which have special reasons for resisting any further diminution in the power and prestige of the national fighting forces. When put to the test the influence of such groups is almost always found to be disproportionate to the noise they make, a recent instance of this being the severe defeat which the "big-navy" party in the United States suffered when Congress ruthlessly cut down the new shipbuilding programme. When that measure first saw the light the world was assured, through the agencies which broadcast naval propaganda in America, that the demand for seventy-one new fighting ships had "nation-wide" support and was absolutely certain to be approved by the legislative bodies. It seemed for a time as if this claim were justified, but gradually, as the true significance of the programme dawned upon the American people, it had to encounter a vigorous and ever-swelling tide of opposition, before which the sponsors of the measure found it expedient to beat a hasty retreat.

To those who have followed the course of events since December, when the programme made its appearance, it is clear that Congress, in striking out all but fifteen of the ships originally demanded, acted in obedience to the nation's will. Carried out in its original form the project would have secured for the American Navy, not merely equality with the sea forces of the British Empire, but absolute paramountcy for the American flag in every ocean to which it could penetrate. The incongruity of launching such a scheme at the very period when the best brains of the civilised world were seeking for practicable means of curtailing preparations for war, and when, moreover, American spokesmen were foremost in urging us in Europe to turn aside from "the Old World policy of competitive armaments," was so apparent that few intelligent observers on this side of the Atlantic believed that the programme would pass through Congress without undergoing drastic amendment. This confidence has been justified by the event. No reflection is cast on the Washington naval authorities by the assumption that they framed their demands on the principle of asking a great deal more than they really expected to get. Nevertheless, in spite of having obtained fifteen new cruisers, which, added to those already completed and building, will eventually give their navy a definite lead over all others in ocean-going cruisers, they affect to be chagrined by the fate of their programme, and are therefore scarcely in the mood to give sympathetic consideration to the latest British proposals. These, it will be recollected, provide for a reduction in the standard tonnage of future capital ships from 35,000 to something below 30,000 tons and the restriction of gun calibre to 13·5in., instead of the 16in. limit now in force. At first sight the proposals seem fair and logical from every point of view. If naval armaments are to be subject to further restriction, the first and most obvious step is to begin with the capital ship which constitutes the backbone of naval power. By an anomaly to which we have more than once adverted, the Washington Conference encouraged the building of exceptionally large and costly battleships by fixing a standard tonnage of 35,000 and a calibre limit of 16in., yet during the war, which had ended only three years before the Conference assembled, the average displacement of battleships never rose above 25,000 tons. Up to the present only two capital ships have been built in conformity with the Washington Treaty rules, and both are British. The "Nelson" displaces 33,500 tons, the "Rodney" 35,000 tons, the armament being in each case nine 16in. guns. Although these vessels are understood to be quite successful from the technical point of view, we gather that naval opinion as a whole does not regard them as good value for the money, each having cost about £8,000,000. Be that as it may, the time is approaching when we shall have to lay down more of these huge and expensive vessels unless the Treaty is amended in the interval. Under the replacement rules of that compact we are entitled to build fifteen new capital ships from 1931 to 1939, inclusive; America is authorised to construct a similar number, and Japan nine. As each new ship is completed it will automatically displace an older vessel, until, by the time our fifteen new mastodons are in service, we shall have scrapped eighteen existing ships, beginning with the "Iron Duke" and ending with the "Hood." This process of deletion is necessary in order to maintain the numerical ratio between the various fleets, but it nevertheless suggests two pertinent questions: first, why destroy ships which may be perfectly serviceable and good for several more years of duty afloat; secondly, why replace each of these ships by a successor of considerably greater tonnage, fighting power, and cost? Both questions admit of simple answers if one is thinking of naval power in the conventional way. But the Washington Conference was summoned, and the Washington Treaty was drafted, with no other ostensible purpose than to put an end to the spirit of competition which had previously inspired the naval programmes of the Powers, great and small. To what extent that purpose has really been achieved still remains to be seen. That the latest British proposals are well calculated to promote it is a statement which cannot, we think, be disputed by any fair-minded person. If, four years hence, the three leading maritime Powers should all proceed to lay down 35,000-ton battleships, each designed to incorporate the maximum sum of aggressive strength as dictated by the tactical views of the various admiralties, then the rest of the world might be pardoned if it smiled rather cynically at this curious sequel to the movement for naval disarmament initiated by the three Powers in question.

It must be said at once that the reception accorded to the British proposals by American

naval representatives is frankly unfavourable. They profess to have discovered an ulterior motive, namely, Great Britain's desire to conserve her alleged naval supremacy by retaining, in the "Nelson" and "Rodney," the two most formidable battleships afloat, while denying America and Japan the possession of ships of equivalent tonnage and armament. We feel sure, however, that arguments of this kind will carry little weight with those who direct American policy. If the objection were pressed, the British Government would, no doubt, be quite ready to agree to the construction of two "Nelson" type ships for the United States Navy, since our aim is not to haggle over a more or less illusory difference in tons and guns, but to foster that spirit of limitation and non-competition in armaments to which our American friends attach so much importance. So far, we understand, the proposals have elicited no formal response from Washington, where, it is to be hoped, they are receiving the consideration they deserve. While there is no urgent hurry, it is desirable that a decision should be come to well in advance of the year 1931, when the first "replace" battleships are due to be laid down, for it is well known that the preparation of plans for a ship of capital rank involves a great deal of preliminary work which may extend over several years. The British plan provides not only for a reduction in tonnage and armament, but for an extension of the useful "life" of a ship from twenty to twenty-six years. Taken as a whole, its acceptance would unquestionably result in a substantial saving of money to all the countries concerned, without any corresponding sacrifice of relative strength at sea. It is encouraging to find the proposals hailed in Japanese official circles as "honest, practical, and capable of forming the groundwork of an agreement which will substantially relieve the taxpayers." Unless American experts are indissolubly wedded to the biggest ship and the heaviest gun, there seems little doubt that the next Naval Conference will result in a sharp scaling-down of the present battleship standard. In any case, judging from recent experience, the "expert" element is by no means the final or decisive element in the moulding of American naval policy.

Load Factor.

The interconnection of power stations, with the possibility thus created of transferring at will the load of an area from one station to another, has obvious merits from the point of view of security of supply. It permits, also, of the holding of a smaller aggregate amount of plant in reserve, for the power of every spare unit is available for transmission to any part of the area. The first of these advantages is gained at the cost of an expensive interconnecting system, but against this must be set the reduction in capital expenditure, owing to the smaller quantity of spare plant which has to be provided. A balance of these considerations determines generally how far a policy of interconnection is justified, but the decision is complicated by secondary, though very important, questions. The chief amongst these is perhaps that of load factor. Defining this in the usual way as the proportion between the average and the maximum load on a station during a year, there would seem to be no justification whatever for the belief, often thoughtlessly held, that the general load factor of any area in England could be improved by connecting up all the power stations in that area. To improve a load factor it is necessary, of course, to find more occupation for the plant—as, for instance, during the hours of night and the summer periods—when it has but little to do. No interconnection between Birmingham and Manchester, for example, could alter the fact that the inhabitants of one city get up, work, and go to bed at the same time as those of the other, and thus their demands for light and power must occur at the same hours of the day. If England could be connected with America, or, better still, with Australia, the case would be very different, but even the most advanced apostles of interconnection have not yet envisaged such an enterprise as that!

Although interconnection on any practical scale cannot have any appreciable effect upon the average load factor of the area concerned, it does permit any desired ratio to be maintained between the load factors of the individual stations serving the area. This introduces very important possibilities, both technical and commercial. For a given cost of a power station per kilowatt installed, the capital charges per unit generated vary inversely with the load factor. A constant ratio between spare plant and total plant is assumed. If, therefore, the load factor could be doubled, the station might be twice as costly per kilowatt of plant installed without increasing the burden of capital charges on the output. Hence, the better the load factor, the more the money that can justifiably be spent in the provision of machinery and apparatus, so that equipment of higher efficiency can be installed with a consequent reduction in the operating costs. Since, however, so long as the demands of the consumers remain unaltered, the improvement of the load factor of one station involves the reduction of the load factor of another, there is a tendency to divide power stations into two classes. On the one hand, there would be the great "base load" stations situated where the best facilities for condensing water and fuel exist and equipped with everything making for economical operation. These stations would be kept as fully loaded as possible all the time, and would produce the bulk of the output as cheaply as modern plant and management would permit. The peaks and fluctuations of the load, on the other hand, would be carried by other stations, in the design of which the main object would be to reduce capital costs on account of the comparative smallness of the output. Savings in fuel consumption effected by the use of efficient apparatus may look large when stated per kilowatt-hour, but if the total number of kilowatt-hours is very small, the aggregate savings may be insignificant when compared with the interest charges on an expensive plant. Since efficiency is so closely allied to the expensiveness of the plant, it is evident that there must be an optimum relationship between the capital costs of the various interconnected power stations and their respective load factors. Common sense indicates that the load shall be so distributed that the best load factor is allocated to the more expensive stations, but the question then arises whether there is such a thing as an optimum load factor, which should not be exceeded. For an isolated plant there certainly is, and its value is a very long way below the theoretical limit of 100 per cent.; 100 per cent. load factor implies a steady load day and night from one year's end to another. That may look desirable on paper, but it obviously cannot be carried safely without a considerable proportion of the plant lying idle the whole of the time, and earning nothing to offset its capital charges. In any practical power plant boilers have to be laid off for cleaning, turbines shut down for annual overhauls, and all the minor apparatus is equally subject to "outage." It is begging the question to argue that at such times a part of the load could be transferred elsewhere if the station were interconnected. Any such transference would reduce the load factor of the station under consideration, so that it would no longer be 100 per cent., as assumed. To maintain this figure, the capital charges of the station would have to be increased by the provision of an amount of reserve plant far in excess of what would be adequate with a lower load factor. Many an engineer has had occasion to thank his stars that his load factor was not as high as theory might warrant. The light load during the small hours of the morning, typical of a bad load factor, permits machines to be examined, minor repairs to be effected and incipient trouble to be prevented from ending in disaster. The relative unimportance of the load at this time also makes a total shut down of the plant of less consequence, should circumstances compel so drastic a step. The small load, also, during several months in the summer provides opportunities for annual overhauls of the plant required for the winter months, and thus reduces the spares which would be necessary with a better load factor. There are station engineers running with load factors not exceeding 30 per cent., who consider themselves safe if they have sufficient machinery to carry the Christmas peak on the normal rated capacity of their plant, with nothing in reserve, trusting to the overload capacity to take care, as well as may be, of any emergency. Few, if any, would be content with such a small margin of security if the load factor were high, and they had not the respite given by the nights, week-ends and summer months to maintain their machinery in good order. It is clear, therefore, that the higher the load factor the less are the capital costs per unit generated up to a certain point only. As soon as the load factor is made so good that the normal facilities for overhauling and attending to the machinery are done away with, extra spare plant has to be provided and the capital costs per unit are raised.

There is another aspect of the load factor which deserves consideration, namely, its influence on the fuel consumption of the station. It is often held that a high coal consumption per kilowatt-hour may be explained by a low load factor, and that a really good fuel figure can only be obtained when the load factor is high. There is a certain plausibility about that contention, because, as everyone knows, generating machinery is more efficient when fully than when partially loaded. It is a false deduction, however, to conclude that a station with a high load factor ought necessarily to be more efficient than another of equal annual output but working with a low load factor. Not only is the conclusion unsound, but experience does not show any appreciable connection between load factor and efficiency, at any rate over the range of load factors met with in central station practice. A moment's reflection will make the matter clear. Figures recently quoted for a turbo-generator give a steam consumption of 9·95 lb. per kWh with a load of 20,000 kW, of 10·20 lb. with a load of 15,000 kW, and of 10·70 lb. per kWh with a load of 10,000 kW. Suppose such a machine to produce 30,000 kWh. in two hours, running with an absolutely uniform load all the time. The load factor will then be 100 per cent., and the steam consumption 10·20 lb. per kWh. Now, suppose the same machine to produce the same output in the same time, but by operating at 20,000 kW for one hour, and at only half that load during the next hour. The load factor would then be reduced to 75 per cent., but the average steam consumption per kilowatt-hour would be exactly the same as before. Even had the machine run idle part of the two hours, so long as the output at the end of the time was the same, the average consumption per kWh would remain unaltered. These figures are sufficient to show how negligible is the effect of load factor on the performance of the turbine plant in a power station. It may be argued, however, that it is in the boiler-house that the effect of load factor would make itself felt, on account particularly of the influence of banking losses. But these are comparable to the no-load losses of a turbo-generator, which we have seen do not affect the question. Experience shows that if the total coal consumption of a power station over equal intervals of time is plotted against the corresponding output, the points so obtained lie along a straight line with practical accuracy. This fact is usually employed as a graphic check upon operating results, by noting the divergence of the record of any shift from the standard line. But the linear relationship of coal consumption with output involves the necessary mathematical conclusion that the coal consumption is unaffected by the load factor. The coal consumption on a light shift will be worse than on a heavy shift, exactly as the steam consumption of the turbines deteriorates as the load diminishes, but load factor, as we have shown, does not enter into the case at all.

Industry, *Science* and Men.

By G. S. BAKER.

To one who in the natural course of events is brought into working contact with many "scientific" and "practical" men, and whose business always involves the possibility, and sometimes the necessity of throwing over preconceived notions, there may come views upon the relations between industry and science which are a little out of the normal, but still may be worth considering. It is not proposed to dwell upon the fact that practically all industry is now based upon a foundation of science. The men who laid the foundations are dead, and this is not an historical essay. But there have been big changes in this last decade in the relations between industry, science and men, and as economic circumstances are compelling the shipbuilding trade to examine itself, the survey of some aspects of industry not connected with the poor scapegoat—the wages of men—should do no harm.

Both industry and science have developed enormously in recent years. The former has become more intricate, "bigger" in the financial sense, separated from all social activities, and is rapidly developing a frankly political side. The latter is remarkable for its abnormal growth in some directions, the entire absence of growth in others and is in serious danger in this country of selling its birthright—of becoming industrialised or alternatively "governmentised"—for the sake of achieving a living for its members.

In a few directions it has been recognised that industry and science must live together, and the wisdom of this course with individual firms, has invariably led to considerable success.

Regard first of all this movement towards separation from social responsibility. One finds it most acute in industry, but it is also obvious in science.

Yet if there is one thing more apparent than any other, it is the falseness of the supposition that either business or science can be separated from social life or even from politics. The recognition of the influence of social life upon industry is about in the same stage now as was the influence of science forty or fifty years ago. Here and there amongst bigger firms a "welfare" man is to be found, occasionally a sports' ground, and these things are regarded as representing a reasonably good and enlightened attitude of the management to the workmen. A Fatigue Board has been set up and has issued several reports, perfectly sound as far as they go but avoiding the larger problem. For fatigue or boredom, or sullenness or ca'-canny is there when the man enters the works—at least most of that which matters. And you may improve his working conditions as regards ventilation, &c., give him good canteens and recreation grounds, but two-thirds of his time is spent elsewhere. Fatigue committees are far too inclined to treat men as if they were standardised parts of a machine, each capable of replacing another, and the unions are adopting the same general attitude, with its logical corollary as regards output, &c., which is so troublesome to the management. But men are reasoning beings, who must feel free if they are to do their work well. For example, a welfare supervisor, whose books can be inspected by the firm, is in serious danger of becoming a suspected person, at the best a mere education officer. Men are interested in their own things, nor can one expect them to develop any special interest in a firm which regards them as pieces of machinery.

We want a science of leisure, or at least some study of this subject, what constitutes leisure, how it reacts upon our mentality and affects our attitude to other things, work included. It would be interesting to have a census taken (if it were feasible) of the manner in which the average man spends his leisure, and the effect of his leisure upon him as a living being. It is one of the serious mistakes of industry to regard men solely as regards their working life. Their object is to live, and although "life" may carry some startling interpretations with a few, it may be accepted that, if by study of their leisure, they were slowly brought to a freer and more wholesome life, their work would become more endurable, be better done, and there would be far fewer strikes. The subject is simpler than appears at first sight, for man's ideas and pursuits as regards himself, taken broadly, have been the same for all time.

Much more striking than this are some of the defects of the scientist. For one thing a philosophy of science seems wholly wanting. It does not seem to have even a guiding principle. For what is the goal of science? To state that science lives for itself, is a law to itself, or is responsible to itself is to evade the question. I think one may say that it should be to improve life or the conditions of life. One of its mistakes is to assume that it is necessary for the world to "advance." But advancement as understood by the scientist is not always progress or improvement, witness his work in the late war. Generally speaking, the scientists' advance merely makes life more intricate, and perhaps cheapens things. Its efforts to raise the standard of living are negligible outside the medical profession. Our chairs of philosophy are moribund and useless, so far as the people are concerned. Here is a great space—the study of how to live—where there is no growth. And alongside of it is another, the science of religion and the principles which actuate the average man. Our ignorance and want of method in these things are painful. Alongside of them we have the enormous modern development of the mechanical sciences. This inequality is bound to mean unequal development, and this is often worse than no development at all.

Science should never be valued for itself, but simply because it aids in the upward progress of man. Science should be used to perfect our minds and our physical being, as well as our machinery. To develop any one much beyond the other is asking for trouble. It is suggested that the over development of factory life compared with physical good being is the main cause of labour trouble. It is suggested that the absence of spiritual development, and overgrowth of the sense of material things of a few people relative again to their environment and being, is a productive source of communism.

Let it be clear that it is not suggested that we should cease working at the mechanical sciences. There are two reasons why we cannot afford to do so, even if we would. The first is that it would be foolish and unscientific. The second is that war is now made by scientists, and whilst our potential enemies employ their best men on war sciences, common sense demands that we should do the same. But although we should and must continue to make new discoveries, which are good in themselves, the extent to which they are good depends entirely upon how they are employed. A wrong application is retrograde, and it is in the minds of very many men that the handling of the products of science by the industrialists during the last few years has not made life easier for the average man, but only for the few. No one can pass through the workmen's suburb of any of our industrial towns, particularly in the North, where most industrial trouble commences, without feeling that this is very true. There is no beauty and no perfection, only grimness and monotony in these streets. This is not a question of wages, nor is it to be improved materially by increasing wages, as the money unfortunately is only spent in an attempt to escape from their surroundings in various, usually incompetent and sometimes harmful ways. It is a question of outlook. Industry wants an attitude towards its workmen which should recognise them as having a life apart from the factory and works, and should not look for immediate results. For it has taken several generations slowly to reduce things to what they are, and will take another to restore them to a reasonable balance.

To give point to this article, I may draw attention to our own industry of shipbuilding. There is no attempt to organise research on any scale commensurate with the importance of the industry. There is but one large organisation of shipbuilding employers, and that organisation by its very constitution is unable to give thought or take any action relative to the dependence of the industry of this country on science and research. It is unable to take any step in connection with the men, except as regards their wages and hours of work. Whilst the leaders of the industry restrict their efforts to these lines, and fail to recognise the other things, it would seem that any effort to keep ahead of our competitors and to obtain tranquility and united effort with their workmen, will be made under very adverse conditions, and the results obtained must inevitably be of a not very satisfactory character.

Literature.

The Principles of Electric Power Transmission. By W. WADDICOR. London: Chapman and Hall. Price 21s.

THE transmission of electric power is now claiming the attention of many engineers, for under the Government's scheme electricity will be transmitted much longer distances than it has been in the past, and it is not surprising that within the last year or so several new books on electric transmission have been published. As all these books clearly show, and as the vast amount of American literature on the subject also indicates, the transmission of power in the form of alternating current presents many problems, and the design of transmitting systems involves many calculations. In technical schools this branch of electrical engineering will no doubt soon claim considerable attention, and the author of this volume has endeavoured to meet students' requirements, although the volume is also intended for designers and engineers responsible for the operation of transmission systems. Unlike several other books that have recently come to our notice, the present volume does not deal exclusively with overhead transmission; it also contains a considerable amount of information about cables. There are, moreover, chapters on protective gear, such as gear for the prevention of dangerous currents, and gear for dealing with pressure rises. The first chapter discusses elementary economic and electrical principles, and shows that, although overhead lines are employed for the highest pressures, it is well within the range of possibility that underground transmission at pressures up to 132,000 volts, may be adopted in certain cases. It is well known that single-core cables working at that pressure are being tested, but, according to reports, multi-core cables working at relatively low pressures, such as 33,000 and 66,000 volts, are none too satisfactory. In this first chapter the author paves the way for the treatment of the more difficult parts of the subject. Subsequent chapters deal with such matters as inductance and capacitance of conductors, the performance of short and long transmission lines, line conductors and supporting structures, the insulation of overhead lines and corona effect, and voltage control by synchronous phase modifiers. The part of the book that is devoted to underground cables is interesting and instructive, and it deals with up-to-date practice in cable manufacture. Special designs of three-core cables, such as the "H" and "S L" cables, are described. Altogether, the book seems to meet the requirements of students who propose to specialise in electric transmission work, and it should also prove useful to engineers who are interested in the subject.

Electro Farming, or the Application of Electricity to Agriculture. By R. BORLASE MATTHEWS. London: Benn, Ltd. Price 25s. net.

No one has made greater efforts to stimulate the use of electricity for agricultural purposes in this country than Mr. Borlase Matthews, whose untiring zeal in this connection is well known to all electrical engineers. On his own 600-acre farm he employs electricity for no less than sixty-seven purposes, and experimental work is carried out on an extensive scale. Another indication of Mr. Matthews' enthusiasm is that he has visited almost all European countries with the object of ascertaining how and to what extent electricity is employed on the farms of other nations, and it is well known that he has delivered many lectures and read many papers bearing upon these visits. In one way and another, Mr. Matthews must have gained a very considerable knowledge of the use of electricity in agriculture, and it is probably correct to say that no British engineer is more capable of writing a book on the subject. As the supply of cheap electricity to rural parts is one of the objects of the Government's scheme, which is now beginning to materialise, the book comes at an opportune moment, and it should prove useful to engineers who are about to grapple with rural electrification problems. Probably few electrical engineers in this country have any real knowledge of agricultural requirements or of how to set about the task of persuading farmers to use electricity, but a study of this volume will help them out of their difficulties. Those at a loss to put their hands on arguments in favour of the use of electricity on the land will find plenty in the present book. Similarly, those requiring technical assistance concerning cheap distribution, the wiring of farms, electric ploughs and other agricultural appliances, will derive much knowledge from the volume. Naturally, much of the information is based on foreign practice, but work carried out in Great Britain is also dealt with. For the benefit of those who are unwilling to wait until a cheap and abundant supply of electricity is made available, the author has provided a chapter on private electric generating in which water power, wind and oil engine plants are dealt with.

The book is well illustrated and is written on simple lines. Some of the chapters are quite entertaining. Although the author does not claim to have covered the entire field, he seems to have considered most of the possible applications of electricity, and as far as we know the book is the only one of its kind published in this country. It should prove useful to all who are interested in the application of electricity to agriculture, irrespective of whether they are engaged in electrical engineering or farming.

SHORT NOTICES.

Locomotive Management from Cleaning to Driving. By Jas. T. Hodgson, M.I. Mech. E. Sixth edition. London: *The Railway Engineer.* 1928. Price 5s. net.—The absence of any large standard work upon the locomotive in the country of its origin has frequently been the subject of comment. But if we lack such a book, for example, as Demoulin's "Traité Pratique de la Machine Locomotive," we have at least several smaller works which appear in new editions at regular intervals. Mr. Ahrons' "Locomotive of To-day," for which, it is to be hoped, a new editor may be found, is one familiar to all locomotive men, and "Locomotive Management," of which the sixth edition lies before us, is another. It is hardly necessary to say much about this book, for it is already well known to those to whom it is especially directed, namely, British locomotive drivers; but we may remind others less closely connected with locomotives that it is an admirable text-book of locomotives and their operation, chock full of drawings and other illustrations and replete with descriptive matter. In this edition it has been brought as nearly up to date as possible—we find, for example, drawings of almost the latest forms of poppet valve gears—and remains one of the most instructive books of the kind that are available. We must also comment upon the price. It has been put low to meet the pockets of the class of readers especially sought, but many a volume at four or five times the price contains much less useful material.

Railway Signalling: Theory and Practice. By S. T. Dutton, M. Inst. C.E., late deputy Chief Engineer, East Indian Railway. London: Crosby Lockwood and Sons, Stationers' Hall-court, E.C. 4. 7s. 6d. net.—In view of the economies in operation which railway companies can effect by signalling, it is probable that no railway subject is more in need of technical literature. Mr. Dutton's book is mainly offered as relating to Indian practice, and although it is a small one—as compared with the size of the subject—for what it contains we have nothing but commendation. The field of signalling is so wide that it is impossible, in a small book of this character, to do more than to touch the fringe of the various aspects, but students, operating officers and even civil and locomotive engineers, who need a knowledge of the principles of signalling, will find in this small work sufficient for their needs.

BOOKS RECEIVED.

Highway Engineering. By J. H. Bateman. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 20s. net.

Tin Mining. By C. G. Moor. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, Kingsway, W.C. 2. Price 8s. 6d. net.

Aerial Photography. By C. Winchester and F. L. Wills. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 25s. net.

Wireless Loud Speakers. Second edition. By Dr. N. W. McLachlan. London: Iliffe and Sons, Ltd., Dorset House, Tudor-street, E.C. 4. Price 2s. 6d. net.

Wire Ropes for Mines: Some Notes Regarding their Manufacture and Use. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 1s. net.

Descriptive Account and Catalogue of the Home Office Industrial Museum and Exhibits. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 3s. 6d. net.

A Comprehensive Treatise on Inorganic and Theoretical Chemistry. Vol. VIII. By J. W. Mellor. London: Longmans, Green and Co., Ltd., 39, Paternoster-row, E.C. 4. Price 63s. net.

Annual Report on the Work of all Departments of the Ministry (Finance) During the Year 1923–24. Part I. Cairo: The Government Publications Office, Ministry of Finance, Dawawin P.O. Price Piastres 20.

Some Modern Developments in Rigid Airship Construction.*

By LIEUT.-COLONEL V. C. RICHMOND.

1. *Introduction.*—It is now well known that the rigid airships at present under construction in this country are considerably larger than any which have been built hitherto. The reasons for this must be looked for in the policy of airship development which is being followed, and they are not primarily the concern of the designer. He may urge that the increase of size enables him to introduce structural improvements which would be impossible with smaller ships, but against this must be set the fresh difficulties which inevitably arise.

Except for the earliest rigid airships constructed in England, the design of all these craft which have been built in any country has followed very closely the pattern evolved in Germany by the Zeppelin Company, after many years of painstaking effort and experience. All those sufficiently intimate with the subject will probably agree that the results which have been produced represent a triumph of engineering efficiency, and it follows that interest must necessarily be very critical in the departures from this pattern which have been made in the design of the airship R 101 which is being constructed by the Air Ministry at Cardington. Some of the changes in design are necessitated by the increase in size, but not all; what are the reasons, advantages, and risks?

It is the hope of the writer that this paper will furnish—at any rate to those who will study the matter sufficiently closely—an answer to some of these questions. It must be realised, however, that the design is hardly out of the drawing-office, the ship is not yet launched. The latter event will furnish the final answer, one way or the other, to a certain type of criticism. This must not be taken to mean, however, that grave risks are involved in these changes—risks which can only be determined by the flight of the airship. Indeed, to anticipate what follows it may be said that this is definitely not the case.

It is perhaps desirable to draw attention to one further point by way of introduction. During the war the pressure put upon the designers in this country was very great. They were asked to produce results comparable if not superior to those produced in Germany after many years of experience. There was little or no time for research and the development of original ideas. It was inevitable that the British rigid airships followed the German ones very closely in pattern. Certain original ideas were successfully worked out by the late Mr. C. I. R. Campbell, such as the "keelless" airship and the improvements in R 38, which were subsequently copied by the Zeppelin Company in

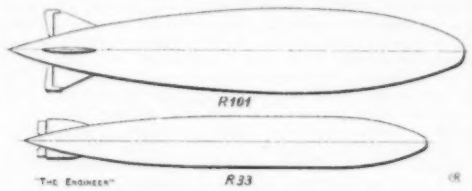


FIG. 1—PROFILES OF R 101 AND R 33

the ZR 3, which is now flying in America. At the time of his death Mr. Campbell was working on the design of a 4,000,000 cubic foot airship which would undoubtedly have represented a considerable advance on previous construction had he been spared to complete it. The loss of the R 38 and her designer was a serious blow to the cause of airship development in this country. That was nearly seven years ago. The long interval has had its advantages. There has been time to carry extensive theoretical and practical research into such problems as aerodynamics, structural detail and mast mooring. The cessation of war has made it possible to get into closer touch with the experts of the Zeppelin Company, to find out the ideas underlying the designs evolved by that company, and to gauge how far these ideas are based on fundamental research, on the experience gained from building a large number of ships, or on the individualism of the designers. With regard to research it may unhesitatingly be said that this country is now at least as far advanced or even ahead of its now friendly rivals in Germany. The experience gained in building so many ships in that country is embodied in the very successful ships produced, especially since the war, and these have been open for the world to inspect and—it must be ungrudgingly added—to admire.

2. *Shape.*—Fig. 1 serves to illustrate the shape and size in profile of R 101 compared with R 33, the latter being, perhaps, the best-known airship in this country. The most important feature which will be evident is the comparatively small fineness ratio (5·5) of the former as compared with the latter (8·15). The reasons which govern a particular choice of shape are primarily aerodynamic ones, but limitations may be put upon the ideal choice by constructional and housing considerations.

Aerodynamic Considerations.—The ideal shape for a given volume is, of course, one in which the drag is a minimum so as to obtain the highest possible speed with a given horse-power, and also the lateral forces are a minimum in order to give the lowest possible aerodynamic loads in the structure. With regard to the latter point it will be obvious that a reduction in aerodynamic bending moments will follow a reduction in the length of the ship. The extensive wind tunnel experiments which have been carried out in this country and in America indicate very definitely the advantage to be gained from the low fineness ratio and the omission of the parallel body. Thus whilst the bare hull resistance coefficient of R 33 in the wind tunnel is 0·010, that of the shape shown above for R 101 is only 0·007, which represents little more than 2 per cent. of the resistance of a circular plate of the same diameter as the maximum diameter of the form. The airship must have sufficient stability and controllability. This is merely a question of sufficient fin and rudder areas, and the wind tunnel experiments do not indicate that with the new forms these need be excessive; in fact, owing to the smooth flow of air over the tail, the reverse is shown to be the case. Now what are the chances of realising these obvious advantages in the full-sized airships?

It is found that these low resistance forms are more seriously affected as regards drag (not stability) by excrescences and irregularities than are the cruder forms. Particular care has had to be taken, therefore, over the design of the power cars, to avoid external bracing to the fins, and to avoid transverse ridges in the outer cover. The estimated overall resistance coefficient of R 101 is 0·0123, as compared with 0·0198 similarly estimated for R 33. The actual full-scale determination of the resistance coefficient of R 33 gave 0·0173, and it is by no means an uncommon occurrence for the full-scale coefficient to be below the estimated one.

Doubt has been expressed in certain quarters over the stability of these forms of low fineness ratio. As mentioned above, this is purely a question of sufficient fin and rudder area, and non-rigid airships having a fineness ratio less than 5 have flown quite successfully and have proved themselves stable. It is interesting and instructive, however, to trace the history of this idea. The little airship "Bodensee" constructed in Germany immediately after the war had originally a fineness ratio of 6·4. It attained, in accordance with the designer's calculations, the high speed of approximately 70 knots, thus justifying the prediction of the low drag associated with low fineness ratio. Speaking in London, however, on this subject, Dr. Eckener, who represents the operating side of the Zeppelin Company, said:—

"It was not possible, of course, in spite of all the progress made in the construction, with such a small ship, to retain the proportion of length to diameter followed up to that time, and at the same time to attain the given carrying capacity. Consequently, the proportion of length to diameter had been considerably lessened. The "Bodensee" was more plump. We should not have dared to take this step if we had not found in our trials in the wind channel that a ship of such width could be sufficiently stabilised by means of fins of not too large a size in order to keep it easily in its course. Nevertheless, on the strength of our trials with the "Bodensee" we came to the conclusion that it is not advisable to reduce the proportion of length to diameter too much, especially with larger ships. The ships become too unsteady and require too much use of the rudder, which naturally diminishes the speed. Consequently a somewhat less extreme proportion was chosen in building the ZR 3."

The designer of the airship—Herr Paul Jaray—when asked to express his views on this point, wrote as follows:—

"I made a point, ever since 1915, of systematically

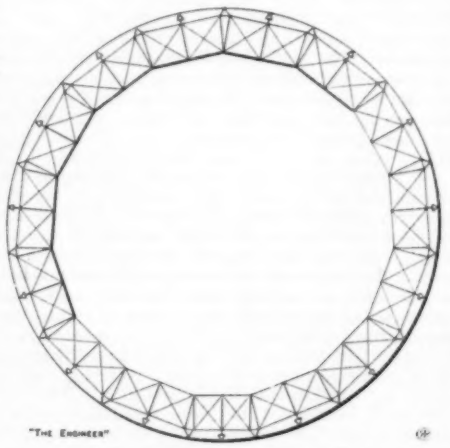


FIG. 3—CROSS SECTION OF R 101

reducing the cylindrical portion, until at last I succeeded in abolishing it entirely in the "Bodensee" for the first time. As a matter of fact the "Bodensee" has attained the lowest coefficient of resistance and the highest actual speed. But with regard to stability I committed an error by fitting much too highly effective rudders to the first really good airship, aerodynamically speaking. The result of this was that the small airship was sadly over-controlled, because the helmsmen who had been hitherto working the former inferior control apparatus on ships, moreover of greater mass and lower speed, were accustomed to greater deflections of the rudder. This gave rise to the impression that the stability of the ship had been impaired. In reality, precisely the reverse was the case, and it was only the constant and unnecessarily excessive movements of the rudder which made the small and speedy ship behave in an 'unruly' way.

"In order to overcome this difficulty I proposed to cut off from the vertical control surfaces the triangular balance with which they were originally fitted and to reduce the size of the rudder. In this way the excessive effect of the rudder should be modified while the leverage on the steering wheel remains unchanged.

"My scheme was carried into operation, but unfortunately at the same time the ship was lengthened in order to increase its range of action, so that the result, 'apparent better stability,' was capable of a twofold construction being put upon it. Whereas Dr. Eckener thought that the lengthening of the airship brought about this improvement, it was really entirely due to the smaller unbalanced rudders, which even at larger angles of inclination, applied in moderation, had no more than the desired effect."

Whichever view of the matter may be taken, it would seem that this one piece of full-scale evidence bearing on the stability of the low fineness ratio forms is not sufficiently definite to discount the results of the wind tunnel experiments, which show such forms to be more (rather than less) stable than the forms of bigger fineness ratio.

In the form of construction adopted in R 101 all girders are jigged off to length before assembly and are finally bolted in place. This requires accurate geometrical calculation, and the contour of the hull must conform to a definite equation. In Appendix I.† a method is illustrated whereby an ellipse may be deformed to give stream-line forms of various characteristics. The method is not novel but is very simple, and this particular application of it has proved very useful in the design of stream-line forms.

(3) *Structural Arrangement.*—Figs. 2 and 3 show typical longitudinal and transverse views of the airship, and attention is drawn to the following special points of interest:—

There are fifteen main longitudinal girders, each an equilateral triangle in section of 30in. side. These are located entirely on the outside of the transverse frames.

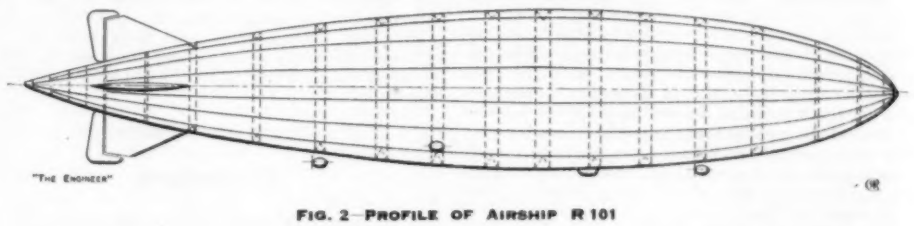


FIG. 2—PROFILE OF AIRSHIP R 101

There are fifteen intermediate longitudinals whose function is merely to co-operate with the main girders in supporting the outer cover. The cross-section of the hull is thus a polygon of thirty sides, the length of each side at the maximum diameter being approximately 13¼ft., the corresponding figure for R 33 being about 10ft. Thus the increase in the unsupported span of the outer cover is not very great. It will be appreciated that the cover can never bulge sufficiently to touch any transverse members, and hence no transverse ridges are presented to the air flow in the surface of the ship. Such ridges were a well-known feature in past airships and accounted for a noticeable loss in speed. The intermediate girders are adjustably connected to the main hull, so that the cover can be retautened when slackness develops by forcing the girders outwards. Expense and weight of redoping is avoided.

The airship has no keel, all the weights being stowed transversely in the main frames. The principal function of the keel in past airships has been to distribute the various loads to the tranverse frames. As a strength member to resist the main bending and shearing in the hull structure, the keel performs no purpose which could not be just as economically performed by distributing its weight amongst all the longitudinals. It introduces, moreover, uncertainties in the stressing calculations.

With the large increase in capacity over previous airships, much greater stowage room is required for fuel, ballast, passengers, &c., whereas the length of the ship has not increased greatly over previous airships. Considerable difficulty would be found therefore in providing adequate stowage in a keel unless it was built very broad. It will be appreciated that by putting the stowage in the transverse frames, considerable latitude is possible in spreading the weights transversely across the bottom of the frames and by this means obtaining a better balance between the weights and the lifting forces of the gasbags and shear wires. This, tends to minimise transverse distortion.

One further point regarding the longitudinals; a system of nets has been devised for containing the gasbags which entirely prevents them laterally loading these girders. At the same time it will be appreciated that with such a large airship, designed for a maximum speed of 80 miles an hour, the aerodynamic forces acting on the outer cover are considerable. It is estimated that a dynamic lift of at least 15 tons may be experienced by the airship at an angle of pitch of not more than 12 deg. This lift can, of course, only be transmitted to the hull by means of radial and tangential forces on the longitudinal girders. The design and testing of these members has had to take these forces into account.

In addition to this there will be still further loads put upon these girders if the internal pressure of the hull is not maintained equal to the surrounding static atmospheric pressure. The loss of the airship "Shenandoah" emphasised—if any emphasis was necessary—the danger of the vertical currents which occur in thunderstorms. A rapid change of altitude will affect the internal pressure both in the gasbags and in the air space between them and the outer cover. Thus the control of the pressure in this air space when the airship is rapidly changing height is a very important matter. It is not possible to keep the pressure in this space exactly equal to the surrounding atmospheric pressure under all circumstances. A system of pressure control has been devised which keeps the departure from this ideal to the lowest possible limits, but the loading caused on the longitudinal girders by such differences of pressure due to this cause as cannot be avoided has been taken into account in the design of these members, on the basis of maximum vertical rate of rise of 4000ft. a minute.

One of the most revolutionary features in the structural arrangement of R 101 is the design of the transverse frames—see Fig. 3. The conventional design for these frames in the past has consisted of a flat polygonal figure braced with radial and chordal wires. The principal loads which these frames have to sustain are:—

(*a*) Lift and gravity loads.

(*b*) Aerodynamic forces transmitted by the longitudinals.

(*c*) Gas pressure on the transverse wiring.

* Institution of Naval Architects, March 30th, 1928.

† Not reproduced.—ED. THE E.

With regard to (*a*) in past airships the weights have been principally carried in a keel attached to the bottom of the frame, whereas the lifting forces from gasbags and shear wires were concentrated largely at the sides of the frames, so that there is a tendency to distort the frame into a vertical oval or pear-shaped figure. The forces under heading (*b*) are inevitable with any type of transverse frame. By far the most predominating forces, however, are found under the heading (*c*), especially when one gasbag is deflated. The result of this is that either a good deal of superfluous weight has to be carried in the structure of the transverse frame under normal flying conditions in order to cover the somewhat exceptional condition of a deflated gasbag, or, alternatively, that a very low factor of safety must be adopted for the deflated gasbag condition. The best published account of the strength of various rigid airships is probably that given by the American designers, Hunsaker, Burgess and Truscott, in their paper "The Strength of Rigid Airships," contained in the *Journal* of the Royal Aeronautical Society for June, 1924. The following extract from this paper on the subject of the strength of transverse frames is of interest: "The factor of safety in the transverse frame in the deflated gasbag condition without any concentration of loads in the keel near the deflated gasbag is 1·21." It is shown in this paper that the transverse strength of the "Shenandoah" to which the above applies, is no less comparatively than that of previous Zeppelin airships. This could hardly be accepted as a satisfactory state of affairs for a large airship designed for passenger carrying under severe weather conditions. Thus considerably more transverse strength appears to be desirable, and linked up with the problem of providing this is the fact that the transverse frames of R 101 are very much larger in diameter than those of all previous airships.

A further objection to the conventional Zeppelin type of frame is that it cannot be stressed accurately. The methods employed in the past have been based on the consideration of the frame with radial wires only, the effect of the chord wires being dealt with by somewhat doubtful approximations. The calculations have also been based on the assumption that the various members are freely jointed to one another, and it is not difficult to show that under the distortion which must inevitably occur, high local stresses may be caused in the case of fixed joints between girders of the depth which would be necessary in such a large frame.

In R 101 an attempt has been made to develop a type of transverse frame and gasbag wiring for the main body of the ship which will overcome the objections mentioned above. This is illustrated in Fig. 3. The single members of the conventional frame are replaced by deep triangular braced structures having the equivalent of a stiff-jointed polygon. This structure is made strong enough to resist all transverse forces without any transverse bracing whatsoever. It lends itself to more accurate stressing calculations than the conventional Zeppelin frame. The arrangement of wiring employed in conjunction with the R 101 frames is illustrated in Fig. 4. By means of this system all end pressures arising from any of the causes mentioned under (*c*) above are transmitted into the longitudinals only and do not stress the transverse frames. It may be likened to a pair of parachutes placed back to back and sharing a common crown which becomes coplanar with the ring when there is no pressure difference. The edges of the parachutes consist of catenary chains to which the wires running over the surface of the bag are anchored. The ends of these chains are, in turn, anchored by bridles to the main joints. If the bags were inflated with air no attachment between the bulkhead and its own ring would be required. Owing to the lift of the gas, attachments are necessary from the bulkhead to the lower half of the ring. The vertical resultant of the forces in these attachments transmits the lift of the gas within the parachute-like ends of the bags. The lift thus applied to the lower portions of the rings is a considerable proportion of the total, *i.e.*, about 50 per cent. The remainder of the lift is transmitted to the frames through circumferential wires, whose tensions are tapped off by means of bridles attached to the joints in each main panel. When one bag is deflated the lift transmitted to the frame through the bulkhead is almost the same as when both bags are fully inflated. The 50 per cent. of the lift which is transmitted to the bottom of the ring can be very nicely balanced against the gravity loads which are suspended there. Considerable adjustment is possible in the tensions of these lower wires; thus, for example, the main tension can be concentrated on the central vertical if a centre line power car is hung there, or can be moved out to the sides of the frame to balance a pair of power cars slung outboard.

Although this type of bulkhead allows an axial displacement of the centre of buoyancy when the partially inflated ship is inclined at a large angle of pitch, yet this displacement varies progressively with the pitch from zero in such a way that there is always a positive righting moment. It avoids, therefore, the unpleasant phenomenon known as "surging" which would occur in the case of an ordinary slack bulkhead. Such a bulkhead is definitely unstable at the mean position, and for a slight pitch of the ship moves over suddenly to its extreme position. This will produce a disturbing moment until the pitch of the ship is such that the centre of buoyancy is again vertically over the centre of gravity.

These frames only require very simple trestles for their assembly, there being one inner and one outer support at each of the fifteen main radial pyramids. They can be lifted by four points only to the mid-height of the shed, where they are allowed to swing into the vertical like a gimbal ring, the side points only being held. Whilst the frames are still lying flat on the ground, all the fuel and water stowage, branch mains, ladders, gasbag nets, &c., can be fixed in place, and then lifted with the frame, so that a large amount of fitting work, which would otherwise have to be carried out at a considerable height above the ground, is avoided.

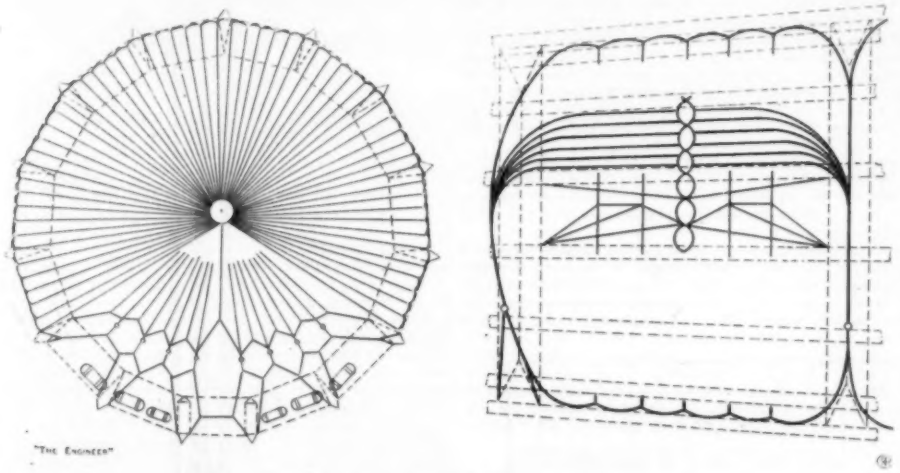


FIG. 4 WIRING OF FRAMES IN R 101

One effect of reduction in fineness ratio is to increase the curvature of the longitudinal girders, and if these were made from straight members, severe discontinuities in the outline would occur at each transverse frame. It is found that these girders can be made to conform to arcs of circles without departing from the theoretical contour by more than a few millimetres. Even with equally spaced gasbags it would not be possible to make all the longitudinals to a common geometrical standard.

Another effect of the decreased fineness ratio is that if all the transverse frames were equally spaced, the volume of each gasbag in the centre of the ship would represent an undue proportion of the total.

It will be seen therefore from the longitudinal view given in Fig. 2 that except for the special spacing at the ends of the ship, the gasbags are made progressively longer as they pass from the centre of the ship towards the ends.

The ship has no intermediate transverse frames. The function of these frames in past airships was connected with the support of the longitudinal girders and with the particular form of shear wiring adopted. It is found more economical in R 101 to adopt a simple form of shear wiring and to make the longitudinal girders sufficiently strong without any intermediate support.

(4) *Structural Detail.*—The outstanding problem in the detailed design of the structure is that of providing much stronger girders of greater span than those used hitherto. The booms of the Zeppelin girders employed in the past were of the well-known open channel section. These girders were remarkably efficient for the small loads they had to carry. It must be remembered that a considerable proportion of the weight of a girder is that involved in the cross-bracing and its attachment to the booms. It has been appreciated for some considerable time that a boom composed of a closed section, such as a tube, is more efficient than an open section of the channel type, but that special difficulties are involved in the attachment of the webs to tubular booms. This problem has been eased to a certain extent by the larger loads which are now called for. Another bar to the development of the tubular girder has been the difficulty of manufacturing tubes having sufficiently high mechanical properties. The Air Ministry has had the valuable co-operation of Boulton and Paul, Ltd., of Norwich, who were developing such tubing for aeroplane work, and who have been responsible for the design and manufacture of a large portion of the girder work used in the hull of R 101. Tubes manufactured from steel and from duralumin strip have been developed, having cross-sections as illustrated in Fig. 6. It is perhaps

FIG. 6 SECTIONS OF LONGITUDINAL GIRDERS

desirable to emphasise here that steel has only been employed in the place of duralumin where weight will obviously be saved. The weight of steel in the complete structure amounts to roughly one-quarter of the total.

It has been argued that from the point of view of corrosion, closed sections are not so good as open ones, because their internal surfaces cannot be inspected. As a matter of fact, it is by no means the easy matter which might be supposed to inspect the internal surfaces of the channels spread all over the hull of the airship. An argument in favour of the closed section is, however, that since the ends are sealed, it is not subject to the continual draughts of fresh air which would cause corrosion. The only really satisfactory means of dealing with this matter is to provide such adequate protection against corrosion as will ensure that no danger can arise from this cause over a sufficiently long period of years, say, ten, at the end of which typical members can be removed and re-tested for strength. The steel used in R 101 is of the rustless variety, having a composition approximately as follows:—

Carbon between 0·12 and 0·16 per cent.
Silicon not more than 0·50 per cent.
Nickel not more than 1 per cent.
Chromium not less than 12 per cent.

In addition the outer surface of the tubes is protected with a pigmented cellulose lacquer. The duralumin is protected by the anodic oxidation process, and extensive tests carried out under conditions of alternate sea water spray and fresh air have shown that this gives the metal remarkably effective protection against corrosion.

Where steel booms are used in the girders the webs are always made of duralumin. The question has been raised of the danger to be anticipated from the differential expansion between steel and duralumin.

The maximum difference of temperature likely to be experienced even in the tropics from the temperature conditions under which the girders were manufactured is of the order of 30 deg. Cent. It can be shown that the stresses corresponding to that difference of temperature represent an almost negligible proportion of the failing stresses of the materials.

The principal members of the transverse frames are called upon to act merely as struts, and for these members the lipped tubes shown in Fig. 6 are used, steel being employed in the ridge members and duralumin in the radial members. The webs are always of duralumin. This form of strut is illustrated in Fig. 5. The webs are continuous and are punched from strip, the process of riveting them between the lips of the booms being a very simple one.

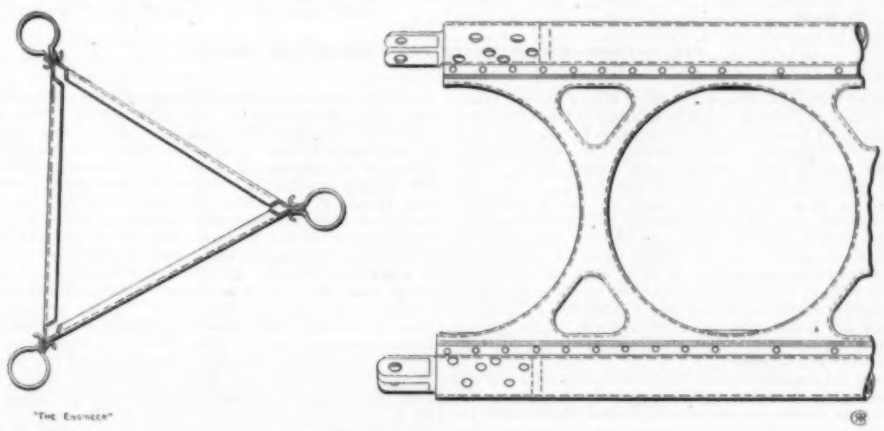


FIG. 5 DETAILS OF A CONSTRUCTIONAL MEMBER

The results of tests on this type of strut in comparison with the standard type of Zeppelin lattice girder are summarised in Fig. 7. This figure gives some idea of the relative efficiency of the different types of girders at various values for the slenderness ratio. The vertical ordinates represent failing load divided by weight per unit length. The specific effective compressive strength of a suitable steel is roughly 50 per cent. greater than that of duralumin, the specific elasticities being about the same. Hence the weight saving possible by the use of steel is enhanced at the lower values of slenderness ratio. This point will be apparent from Fig. 7, in which it will be seen that with the general choice of ratio which has been made the efficiency of the new girders is considerably above that of the Zeppelin type girders. The general arrangement of the structural members of the ship is part of an harmonious scheme for utilising such efficient members and working within this slenderness range. In this connection it must be remembered that the joints and end fittings for girders must represent quite a considerable proportion

of the total weight of the structure. A compromise is therefore to be struck between the slenderness ratio chosen for the struts and the consequent weight of end fittings.

The booms of the main longitudinal girders consist of seamed tubes as illustrated in Fig. 6, page 411. The girders are cross braced with struts and wires, the bracing struts being located on the booms by means of die-cast sockets, the socket being secured by a bolt which carries stirrups into which the bracing wires are screwed. This construction lends itself very readily to the assembly of girders of different curvatures. Girders of this type are capable of internal stressing calculations which enable the loads in their various components to be calculated for different conditions of end and lateral loading. The girders are cambered as has been explained above, and the ultimate strength depends on the ultimate deflections which occur. These can be calculated by a system of successive approximations, and the test results agree remarkably well with the calculations. The ends of all tubular booms are finished with sockets carrying forks whereby they may be bolted to the adjacent girder, or to the duralumin die stampings which form the joint elements. These die stampings form a very compact joint and are a convenient manner of ensuring that the neutral axes of all the girders meeting at a given joint shall pass through a common point, and that any loads suspended from the joints shall also pass through the same point, so that there is no offset loading at the joints whatsoever. The joints employed in all past airships have consisted of a collection of gusset plates which have been very complicated to manufacture and which have given a very indefinite partition of load at the joint. The type of joint described for R 101 facilitates very rapid erection or replacement. All bracings are provided with screwed terminals so that the adjustment of their tension can be easily carried out, as can also the subsequent trueing-up of the hull structure should distortion develop with wear.

5. *Structural Tests.*—Very extensive tests on the new types of girders have been carried out, a special machine having been built at the R.A.E. to accommodate the large longitudinal girders. Approximately fifty examples of the composite steel and duralumin ridge struts for the transverse frames have been tested in families to trace the effect of variation in gauge and also of variation in manufacturing accuracy. Similarly about twenty-five all-duralumin members used in the radial struts have been tested. Some of the results have been summarised in Fig. 7. A large number of tests have been made on the longitudinal girders under combined end loading and lateral loading, and the results obtained have agreed very well with the calculations, which can be made both on the failing strength of these girders and on their ultimate deflections close to failure. In cases such as close to the nose, where the camber of the girder is heavy and the anticipated tensions are high, tests have been made under tension as well as under compression, the machine being specially adapted for this purpose.

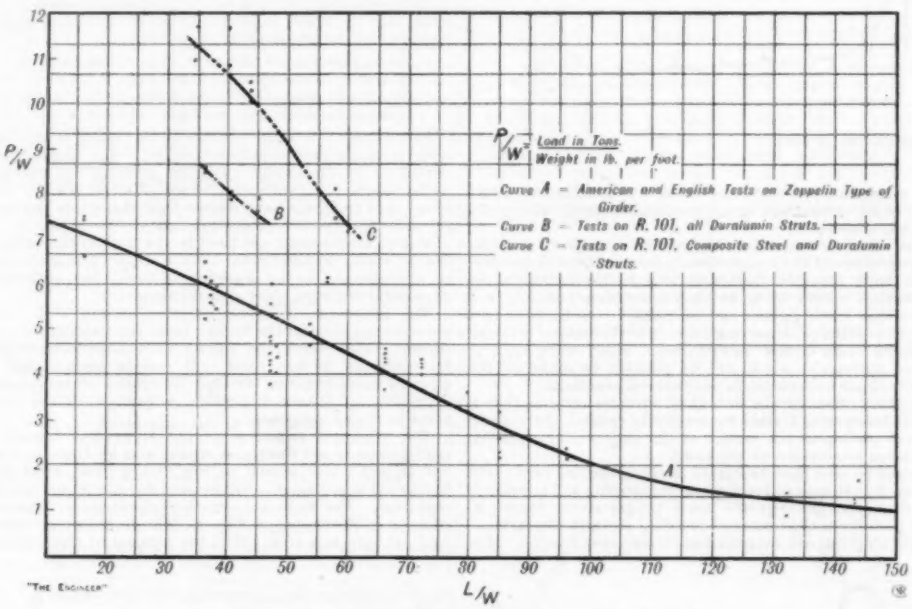

P/W
L/W
P/W = Load in Tons / Weight in lb. per foot.
Curve A = American and English Tests on Zeppelin Type of Girder.
Curve B = Tests on R. 101, all Duralumin Struts.
Curve C = Tests on R. 101, Composite Steel and Duralumin Struts.
A
B
C
"The Engineer"

FIG. 7—COMPARATIVE TESTS OF GIRDERS AND STRUTS

Before the construction of the main hull framework was commenced a complete replica was built of a centre bay of the ship, consisting of two transverse frames and the connecting longitudinals and shear wires. Special electrically recording strain gauges were developed with the co-operation of the Cambridge Scientific Instrument Company, which enabled the strains in the various members to be watched during the progress of the tests, all the girders having been previously calibrated for strain during the girder tests referred to above. One of the transverse frames was subjected to a large variety of loading tests before being assembled into the bay, both in a horizontal and a vertical position.

The complete bay was attached to the door of the shed by means of a flexible end plate on each longitudinal girder. The bay was allowed to project from the door as a cantilever without any other support than its fixing to the door. Tests were carried out with the bay empty of gas with loads slung from the bottom of the ring remote from the door, thus shearing this ring downwards with respect to the door. A gasbag was then inflated in the bay and all weights removed so that the full upward shear caused by the lift of the gas came on the bay. No strains were anywhere recorded in the transverse frames higher than the calculated values. The limiting conditions of loading on the largest frames are roughly as follows :—

The maximum lift on a frame is approximately 15 tons balanced by 8–9 tons of concentrated weights, plus the remainder of weights practically equally distributed round the periphery. It has been explained above that with the system of netting adopted approximately 7½ tons of lift is concentrated at the bottom half of the frame, and the other 7½ tons at the sides of the frame, when two adjacent gasbags are fully inflated or when one is fully inflated and its neighbour is empty. When one or both of the two adjacent gasbags are not fully inflated the deficiency in lift has to be made up by the shear wires which apply their lifting components principally at the sides of the frame. It is estimated that with the ship full of passengers but practically empty of fuel, at the end of a voyage, the state of inflation of the gasbags will be such as to give a concentrated lift at the bottom of the frames of from 3 to 4 tons. The total weight which will not be locally balanced in this region may therefore amount to approximately 5 tons. The empty bay was tested with the total weight of 6 tons divided equally on the two bottommost joints, and represented, therefore, both in magnitude and disposition a more serious condition of loading than is likely to be experienced in practice. No abnormal strains were recorded in the ring girders. The deflections are of interest. The topmost point of the frame dropped 1·2in. and the bottommost point 5·3in.; the extension of the vertical diameter was thus 4·1in. Remembering that the diameter of the frame is 130ft., it will be appreciated that the ring structure is very stiff. For instance, let it be imagined that a 6-ton weight is suspended on a wire 130ft. long whose failing strength is 24 tons. It will be found that the extension of the wire under this load is approximately 4in.

A test was also carried out with the 6 tons divided into two units of 3 tons each, and hung on the third joint up from the bottom to represent a case of power car loading. Under these circumstances the lengthening of the vertical diameter was only 0·2in.

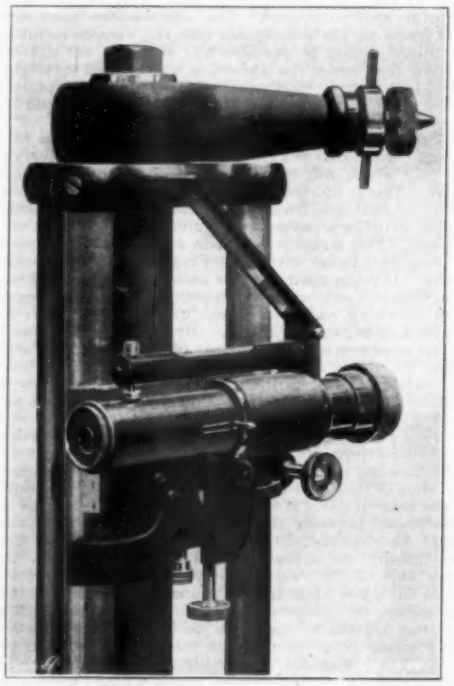
Another limiting case of ring loading is that in which the whole of the concentrated weight in the form of 8 tons of fuel may become completely used up, whereas there is the full lift of 7½ tons from the gasbags concentrated on the bottom of the frame. This was represented by the test described above, in which all weights were removed when the gasbag in the test bay was fully inflated. The deflections recorded under this test were, an upward deflection at the top of 0·28in. and at the bottom of 2·62in., thus giving a diminution of the vertical diameter of 2·35in. The strains recorded in the shear wires of the bay revealed two points of particular interest. The first was that owing to their stiffness and continuity the main longitudinals were found to resist about 25–30 per cent. of the shear, thus relieving the shear wires of this load. Secondly, it was found that the distribution of loads in the various shear wires did not follow strictly in accordance with the common stressing assumption of "plane sections," in spite of the relatively small distortions of the transverse frame recorded above. The effect was doubtless exaggerated by the fact that there was no second bay adjacent to the frame which was being loaded, but it was found that there was a tendency for the load in the shear wires to be above the calculated value in the region of the concentrated loads. In general terms the effect of a concentrated load may be described as producing a blister in the shell of the hull in its neighbourhood. The tests described provided the data on which it was possible to take account of these two secondary effects in the final design of the hull framework.

In the course of a paper on "The Influence of Metals on Workshop and Design Problems," read by Mr. A. H. Goodger, M.Sc., before the Manchester Association of Engineers, the author pointed out that it is often stated that cast iron should not be cast too hot on account of the increased size of the graphite flakes, but with the dense and strong irons which are required in important castings to-day experience indicated, he said, that they should be poured as hot as the metal can be obtained. The author's experience with large castings cast from low-silicon low carbon irons appears to confirm the recent work of Piwowarski, that high-temperature melting of cast iron improves the strength. The "fair" casting temperature is also much modified by such matters as thickness, method of running, size of runners, distance the metal has to travel, &c.

A New Form of Cathetometer.

A CATHETOMETER is an instrument used in physical and similar laboratories for measuring, at a distance, differences of vertical height. In essence it is a very simple piece of apparatus. It need only consist of a horizontal telescope mounted to slide on a vertical graduated rod or post. With the post set truly vertical and the telescope truly horizontal, a sight is taken through the telescope on to one end of the distance to be measured, say, the height of the mercury column in one limb of a U-tube. A reading of the height of the telescope on the post is then taken, and the telescope is re-sighted, by adjusting its position on the post, on to the other end of the height to be measured, that is, in our example, on to the level of the mercury in the second limb of the U-tube. The difference between the readings on the post gives the difference of height sought. It will be understood that as the telescope is horizontal in both positions the scale on the post is full sized and gives a full sized reading of the dimension being determined.

THE CASELLA CATHETOMETER

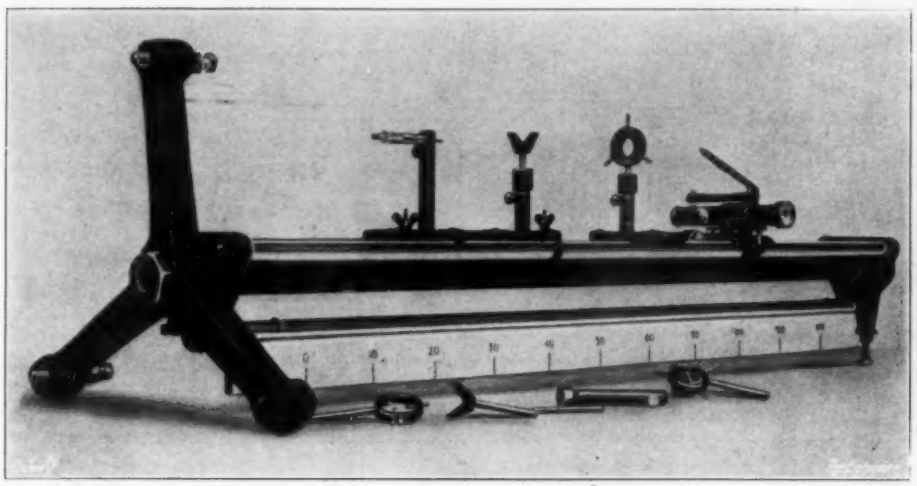


TELESCOPE AND CARRIAGE

Simple as the instrument is its design permits of the exercise of scientific skill and in its execution calls for the display of good workmanship. The common form of cathetometer follows the lines we have indicated, that is to say, it consists of a base supporting a vertical graduated rod carrying a sliding carriage, on which there is mounted a telescope with its axis horizontal. A considerable advance on this elementary design has recently

CATHETOMETER ARRANGED AS AN OPTICAL BENCH

C. F. CASELLA AND CO., LTD., LONDON, MAKERS



been made by C. F. Casella and Co., Ltd., 49 and 50, Parliament-street, London, S.W. 1, who have produced the cathetometer which is illustrated herewith.

The new instrument consists of a heavy cast iron tripod base fitted with levelling screws, a central steel column rising from the base, a cage surrounding the central column consisting of three brass rods fastened to two triangular brass castings, and a telescope element mounted to slide up and down on two of the brass rods. The two triangular ends of the cage are arranged to revolve round the central column on ball bearings. The rod carrying the telescope is engraved with a scale 1 m. long. A clamp is provided to hold the cage fixed to the column and fine adjustment of the cage in azimuth is obtained by means of a tangent screw which works against an opposing spring to take up back lash in the usual way. The telescope is mounted on a carriage which bears at three points on two of the brass rods. This carriage is of the compound type. After it has been clamped to the cage, the operation of a fine motion screw permits the height of the telescope to be exactly adjusted. In addition, a fine motion screw permits the angular setting of the telescope in the vertical plane to be varied through a small range in order that the telescope axis may be set truly horizontal. A spirit level is fixed on top of the telescope, and above the level a mirror is set at such an angle as to permit the bubble to be seen from the eye-piece end of the telescope. The telescope slide is fitted with a vernier reading to 0·05 mm. The focussing of the telescope is carried out by the sliding of an internal lens and covers a range from 1 m. to infinity. The object glass is a sliding fit in the tube and can easily be withdrawn and replaced when required by a microscope object glass.

The accuracy of operation of the instrument depends upon, among other factors, the accuracy with which the bars of the cage are initially set vertical and the axis of the telescope horizontal. The procedure adopted to secure this end is of considerable interest. The apparatus is set up at the desired spot, and the levelling screws in the base are adjusted until the bubble of the telescope spirit level shows horizontality. The cage is then swung round the central column through 180 deg. In general, the bubble will now be found to be off the central position. Let x be the number of divisions by which the bubble as a result of the rotation has moved away from its central position. It is restored to that position by adjusting the base levelling screws until the bubble shows a departure of $\frac{1}{2}x$ and then by adjusting the telescope tilting screw until the bubble is at zero. The cage is next turned through a further 180 deg. The movement of the bubble should now be less than x divisions. It is again eliminated half by adjusting the base levelling screws and half by adjusting the telescope tilting screw. The process is repeated until the bubble shows no departure from the zero position when the cage is rotated through a complete turn. In this condition the bars of the cage must be vertical, and the axis of the telescope horizontal.

The instrument can be set up horizontally, as shown in one of our engravings. For this purpose the top end of the central column is fitted with an arm carrying an elevating screw. In the horizontal position the instrument can be made to serve as an optical bench. Various lens carriers and other fittings are supplied to give effect to this use of the instrument. One of the fittings is a micrometer, and by its use the instrument can be converted into a comparator. Yet another use can be found for the instrument in the horizontal position. With a divided scale hung on the lower of the three bars forming the cage the instrument can be made to serve as a reading telescope for use in conjunction with a reflecting galvanometer.

Canadian Engineering News.

(From our own Correspondent.)

Nickel and Copper at Sudbury.

Discussing the nickel deposits of the province of Ontario during the course of an address delivered in Toronto recently, Hon. Charles McCrea, Minister of Mines for Ontario, said it was estimated that there is sufficient ore in sight in the mines of Sudbury to sustain the present output for the next 175 years. This means that Ontario will continue to supply 90 per cent. of the world's nickel for nearly two centuries to come, unless greater or richer deposits are found elsewhere. In addition to its immense nickel reserves, the Sudbury area is proving to be a rich repository of copper, particularly at the Frood mine, mainly owned by the International Nickel Company, but partly also by the Mond Nickel Company. As a result of diamond drilling, an immesne body of high-grade copper ore has been found at a depth below 2000ft., and the International Company proposes to erect an electrolytic copper refinery to treat this large ore body. The famous Creighton Mine, whose past performance has gained for it the reputation of being the greatest nickel mine in the world, is also showing at depth rich copper ore.

Power Extensions in Ontario and Quebec.

The Canada Northern Power Corporation, which controls the power supply in the mining districts of Northern Ontario and North-Western Quebec, is now spending about 3,000,000 dollars on various extensions to its properties, to take care not only of the present, but of future needs. It is augmenting its power and transmission line capacity in all directions where the demand for power appears to be increasing. A 44,000-volt transmission line from Indian Chute to the Kirkland Lake mining field has recently been completed; a 110,000-volt line from the Quinze plant in Northern Ontario to the Kirkland Lake district is now under construction. A 50-mile, 110,000-volt line from the Quinze plant to the Rouyn mining district, in the province of Quebec, was recently completed. There are now two 110,000-volt circuits, extending from the Quinze plant to the sub-station in Porcupine, a distance of about 123 miles, and from this line a branch is extended from a point near Elk Lake to the Gowganda silver area, a distance of approximately 20 miles. The present expansion programme is linking the various plants and transmission lines into one inter-connected system, so that extra loads in one section may be borne by the whole, and water shortages at one plant may be met by supplying energy from others.

Proposed Power Plant on the Montreal River.

Investigations and surveys are being carried out preparatory to the construction of a power plant at the Upper Falls, on the Montreal River, in North-Western Ontario, for the Great Lakes Power Company. The work of construction will probably take two years, and will involve an expenditure of 2,500,000 dollars. The additional power will enable the Algoma Steel Corporation to expand its operations at Sault Ste. Marie, Ontario. It has been announced that extension of the Corporation's plants will involve ultimately between 10,000,000 and 12,000,000 dollars. The company proposes to extend immediately its plant for the fabrication of structural sections up to 15in., providing the steel industry's request to the Canadian Tariff Board for greater protection is granted by the Government.

Power Development on the St. Lawrence.

Keen interest is being manifested in Eastern Canada over a big projected scheme of power development on the St. Lawrence River in the Beauharnois district, in the vicinity of Montreal. Powerful financial interests of Toronto and Montreal are contemplating a huge development by means of a power canal about 12 miles long, on the south side of the river from the vicinity of Hungry Bay to Melochville. The potential development in this area is nearly 2,000,000 horse-power, and the canal would be of sufficient size to permit navigation by large boats. The combined power and navigation waterway will begin at Hungry Bay, near Valleyfield, Quebec, on the south side of the St. Lawrence, and carry ships past the Coteau Rapids, the Cedar Rapids, the Split Rock Rapids and the Cascades. As the first-named have a drop of 15ft., the Cedars 30ft., and the Split Rock and Cascades 24ft., and there is an additional drop of 14ft. at other points, this means that at Melochville, where the power-house will be situated, the water will be given a plunge of 83ft. That is the difference between the levels of Lakes St. Francis and St. Louis. At first the power-house will be given an installed capacity of only 500,000, horse-power. The cost of the canal and electric equipment will be about 65,000,000 dollars, of which 15,000,000 dollars is credited as the cost of navigation works.

Proposed New Railway.

Reports are current in Canada that the British syndicate headed by Lord Gainsford and Sir George Courthope, which is planning to spend many millions of dollars in industrial development in the province of Quebec, will build a railway from St. Felicien to Lake Chibougamu. This will be one of the biggest developments ever undertaken in the province. Lake Chibougamu is the centre of what is claimed by geologists to be one of the biggest copper mining fields in the Dominion. It is situated about 200 miles from St. Felicien, in the Lake St. John district. This project is entirely separate from the St. Felicien to Mistassini railway scheme, which the same syndicate will undertake. The Quebec Government some time ago granted a subsidy of 192,000 dollars for the St. Felicien-Mistassini line of 32 miles in length, and a further 375,000 dollars for the continuation of the line to Chute-a-Caron, on the Saguenay River, where the big plant of the Aluminium Company of Canada is being erected.

A New Telegraph System.

Plans are under way in Canada to connect Montreal and Vancouver by a new high-speed telegraph system, or "wired wireless," as it has been called, which is being installed by the Canadian National Telegraphs at a cost of 2,500,000 dollars. The carrier current system, which is being used and which is practically the application of the wireless audio-frequency principle to wire service, will make it possible, it is stated, to transmit eighty-four messages simultaneously, including the human voice, in both directions. The new system uses two wires, whereas the old system used one wire over which eight messages could be sent simultaneously. The installation of the new equipment between Montreal and Winnipeg has already been completed.

A Large Papermaking Machine.

The largest papermaking machine yet to be built in America is that ordered by the Backus-Brooks Company, of Minneapolis, U.S., for the newsprint mill of the Great Lakes Paper Company, Fort William, Ontario. The machine, which will make paper 304in. in width, will be 348ft. in length and will weigh close on 5,000,000 lb. There will be forty-eight dryers on the huge machine and it is expected that it will be capable of producing 1500ft. of newsprint per minute.

New Contracts.

Several Canadian engineering firms benefit by contracts placed recently by the Back River Power Company for equipment for its projected 8,000,000-dollar power plant on the Back River, near Montreal. The Canadian General Electric Company will supply all electrical equipment, generators, &c. The Dominion Engineering Works, Ltd., and the Canadian Allis-Chalmers Company, Ltd., will share in the work of building the necessary water wheels involved in the undertaking.

Shipments of Iron Ore.

Between January 1st and December 11th, 1927, the record tonnage of 1,151,923 tons of iron ore was taken from the mines of Newfoundland. Production was confined entirely to the Wabana Mines at Bell Island. Shipments totalled 1,333,622 tons, of which 800,000 tons went to Germany, 61,030 tons to the United States, and 472,592 tons to the furnaces of the operating company, the Dominion Iron and Steel Company, Sydney, Nova Scotia.

The British Empire Steel Corporation.

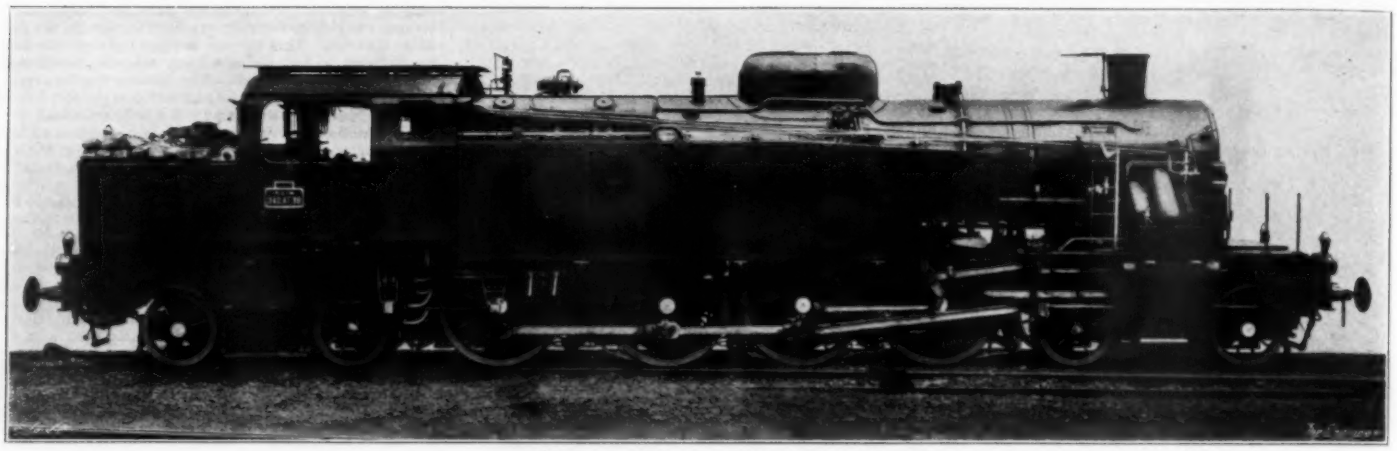
Acquisition of control of the British Empire Steel Corporation by the Holt-Gundy interests is the subject of a great deal of discussion in Canada at present, the consensus of opinion being that it will prove a development of very beneficial influence which will be felt throughout the Dominion. From a study of the records of the men who have just become identified with the corporation, assurance is given that operations will be placed on a sound and economical basis, to the ultimate benefit of every one concerned. It is understood that a sum of about 5,000,000 dollars was involved in the purchase of the controlling interests of the Dominion Steel Corporation, Ltd., which, in turn, controls the various subsidiary companies embraced in the British Empire Steel Corporation, and that sufficient capital will be available to rehabilitate the entire industry at Cape Breton, Nova Scotia, the figure of 15,000,000 dollars being mentioned in this connection. President Roy Wolvin has resigned and has been succeeded as head of the corporation by C. B. McNaught, of Toronto, while Sir Herbert Holt, J. H. Gundy, George H. Montgomery, G. H. Duggan and W. E. Wilder have become members of the board of directors. The corporation enters the new era at a time when the industrial outlook of Canada is regarded by leading men as particularly bright. A great deal is expected of the coal business of the corporation. The new interests which are at the helm represent industries which are large users of coal, and it is thought that this should be quite a help.

Utilisation of Lignite.

The opinion has been expressed by members of the Bureau of Industries of the Province of Saskatchewan, that great industrial activity will follow the opening of operations at the lignite experimental plant at Bienfait, which has been taken over by the Western Dominion Collieries, Ltd. It is expected that in the process of carbonisation which will precede the manufacture of briquettes a large amount of gas will be released, variously estimated at from 2080 cubic feet per ton of residue to 5500 cubic feet, the amount being dependent upon the system in use. This gas, while not of high calorific value, will be cheap and plentiful, and it is expected will be capable of being piped easily to any industry in the neighbourhood, and particularly to the brick and tile industries and other ceramic works, now established or being established in the locality. In addition to this another by-product will be coal tar, producing about 80 lb. to the ton of raw material used. Either this may be distilled into pitch for the necessary binder for the briquettes or be refined to creosote and other products of coal tar. A chemical plant thus becomes a possibility for the utilisation of this product. There is readily accessible to the Bienfait lignite field a large deposit of volcanic ash, the development of which it is expected will follow upon the release of gas power from the coal.

P.L.M. RAILWAY—EIGHT-COUPLED COMPOUND TANK ENGINE

MONSIEUR VALLANTIN, PARIS, ENGINEER



P.L.M. Railway 4-8-4 Tank Engine.

The Paris, Lyons and Mediterranean Railway Company built last year ninety exceedingly fine eight-coupled compound superheater tank engines with leading and trailing bogies. These engines embody the most modern practice of this railway and are the logical sequel to the six-coupled tank engines built before the war. They are fitted with separate regulators and reversing gear so as to give the driver easy control when running either chimney or bunker in front. To facilitate movement on curves the second and third pairs of coupled wheels have the flanges of the wheels turned down to give increased side play. The tractive force is 35,926 lb. The principal dimensions, &c., are as follows :—

Boiler pressure	227 lb. per sq. in.
Grate area	33·12 sq. ft.
Heating surface—	
Fire-box	173·61 sq. ft.
Tubes	1690·11
Superheater	543·37
Total	2399·38
Boiler, length of tubes	17·9ft.
Tubes, steam	95
Tubes, superheater	21
Safety valves, muffled	2
Injectors, "Universelle"	2
Cylinders—	
Diameter, H.P.	15·5in.
Diameter, L.P.	24·8in.
Stroke	25·7in.
Weight—	
Empty	91·2 tons
Water	2640 gallons
Coal	5 tons
In running order	115 tons
Length over buffers	58ft. 6in.

Special fittings; fire-box stay bolts in manganese bronze; Trefoil variable exhaust; hand-worked by-pass; Westinghouse and non-automatic air brake; three pressure gauges, showing boiler, high-pressure, and intermediate receiver pressures, two on the boiler and one when running bunker first; a sight-feed lubricator with five feeds; steam sanding apparatus; steam heating; Flaman speed indicator; an indicator of the position of the signals when at danger.

Our thanks are due to Monsieur Vallantin, Ingenieur-en-Chef Materiel et Traction, for the photograph reproduced above, and for the particulars given in these notes.

INSTITUTION OF ELECTRICAL ENGINEERS.

SUMMER MEETING IN SCOTLAND.

Following upon the decision to abandon the arrangements for the proposed summer meeting in Norway, the Council of the Institution of Electrical Engineers has received and accepted an invitation from the Committee of the Scottish Centre, of which Mr. D. M. Macleod is Chairman to hold the summer meeting in Scotland. The following tentative programme has been prepared:—The party will assemble in Glasgow on Monday, June 25th. In the morning of the Tuesday there will be a reception at the University of Glasgow, which will be followed by a visit to the new Falls of Clyde hydro-electric station. In the evening there will be a conversazione and dance at the Central Station Hotel, Glasgow.

On the Wednesday the party will proceed by special train to Edinburgh, where the day will be spent in visiting the Portobello generating station, the works of Bruce, Peebles and Co., Ltd., and places of national and historical interest. The return to Glasgow will be made by special train.

On the Thursday morning the members will leave Glasgow by special train for Fort William and will visit Lochaber to see the work in progress on the power scheme. The night will be spent at Fort William. The next morning an inspection will be made of the British Aluminium Company's new works, &c. Afterwards there will be an extended steamer excursion. The night will be spent at Oban and the meeting will close on Saturday, June 30th.

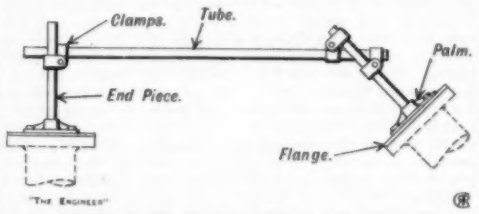
Further particulars may be obtained on application to the Secretary of the Institution, Savoy-place, Victoria Embankment, London, W.C. 2.

A Universal Pipe Template.

We have received some particulars from L. Ferguson, Ltd., of 95, Bath-street, Glasgow, C. 1, of an ingenious device for taking the place of the wooden templates usually employed when a "special" pipe has to be made to fit in between two existing flanges. It is known as Sturrock's universal pipe frame and is illustrated by the accompanying cut.

The frame is built up of solid-drawn steel tubing jointed together by die-cast clamps of high-tensile bronze. The terminal parts of the frame are comparatively short lengths of tubing on to which there are screwed palms of cast aluminium. These palms are accurately drilled through a jig for four bolt holes.

In using the device light plate flanges are made to correspond with the flanges of the existing pipes and are bolted on to the aluminium palms. The flanges and palms are then bolted on to the standing pipes and the frame is completed by clamping together such lengths of tubing as may be necessary to join the two palms. The frame illustrated is a comparatively simple affair, but it will be readily understood that almost any shape can be built up and that, if necessary, diagonals can be put in to



The Sturrock Universal Pipe Frame

brace a large frame together. Generally, however, the bronze clamps provide sufficient rigidity to keep the palms in place. If the frame has to pass through holes in decks or bulkheads, out of which it could not be withdrawn whole, it can be made with a joint in any convenient position by means of two of the aluminium palms. It can then be parted for withdrawal with the certainty that it will re-assemble accurately.

When the template has been made it is sent to the pipe shop and a "negative" is there made up of similar framing. That is to say, the new frame is made with the aluminium palms facing the opposite sides of the template flanges. The first palms are then unbolted from the flanges and the original frame is released for further service. In the interval the pipe wanted can be made to fit the negative template and drilled, with the assurance that it will fit in place without further adjustment.

The saving which can be effected by the arrangement just described needs little emphasis. It is unnecessary to bring in the help of a woodworker, as is usually the case, for the production of a template, which generally results in the time of both the pipe fitter and the joiner being occupied during the necessary process of explanation, for the work can be carried out by the pipe fitter himself; and the template material may also be used over and over again instead of being put on the scrap heap, as is generally the case with wooden templates.

Liquid Fuel from Coal.

At a meeting of the Diesel Engine Users Association, which was held on March 30th, Mr. David Brownlie read a paper on "Liquid Fuel from Coal."

The author dealt in considerable detail with the importance of the question from a national standpoint, and said that the production of liquid fuel from bituminous coal and other carbonaceous material was a vital matter to those in Great Britain who were connected directly or indirectly with the development of the Diesel engine, either as stationary power plant or for locomotive purposes. Further, the production of liquid fuel from coal formed part of an alteration in the whole national view point, chiefly in the shape of a scientific development to the fullest extent of the resources of the country, which, he suggested, would have to be accomplished almost immediately, if Great Britain was to maintain an outstanding position in the world. The nation, he went on to say, had been drifting for years past into a serious situation, largely because of the lack of scientific methods, especially with regard to coal and the production of liquid fuel. Unfortunately, the enormous technical advances that one understood were being made in Germany, and to a lesser extent in France, both with hydrogenation and the manufacture of synthetic fuels, chiefly from carbon-monoxide, were kept a jealously guarded secret, which, of course, was very natural in the circumstances.

There was, he pointed out, an enormous field in Great Britain for the oil engine, certainly to the extent of several million horse-power, especially when modern super-power stations persisted in burning raw coal under steam boilers as mere fuel, without recovering the by-products and throwing away from 50 to 60 per cent. of the total heat of the coal in the cooling water. When the Diesel engine was combined with an exhaust steam boiler, the field open would be still greater, including industrial establishments having much more power than process steam requirements.

The amazing development of water power in nearly every country, which was illustrated by figures given in the paper, was one reason why, instead of selling British coal at ridiculous prices, it would become compulsory to treat the coal on scientific lines, including the production of liquid fuel.

There was a popular idea that low-temperature carbonisation was a discovery of the past twenty years or so. This was, of course, not true. The value of a low and carefully controlled temperature with progressive heating and absence of cracking and decomposition of the oil, both as regards quality and quantity, was understood thoroughly and practised on a large scale over seventy-five years ago.

The author then mentioned some seventy-five low-temperature carbonisation processes, and made a brief reference to thirty of the more important processes, which at the present time actually have large-scale plants in more or less continuous operation. What is now generally termed the "synthetic liquid fuel" method was then referred to, and, in conclusion, the author remarked that an indication that the time was rapidly becoming ripe for low-temperature carbonisation was to be seen in the remarkable advance made during the past few years in pulverised fuel firing. He thought that the solid carbonised product from any process was eminently suitable for this method of furnace operation.

LAUNCHES AND TRIAL TRIPS.

Acosta, single-screw oil tank steamer; built by Palmer's Shipbuilding and Iron Company, Ltd., to the order of Venezuela Gulf Oil Company, of Caracas; ran successful trial trip, March 26th.

Cabo Espichel, single-screw tug and salvage steamer; built by Harland and Wolff, Ltd., to the order of McKie and Baxter, Ltd., for the Lisbon Harbour Board; dimensions, 135ft. B.P. by 27ft. by 13ft. 6in. Engines, triple-expansion, surface condensing type; constructed by McKie and Baxter, Ltd.; handed over to owners after running successful trial trip, March 27th.

Bradfyne, steamship; built by Wm. Gray and Co., Ltd., to the order of Sir William Reardon, Smith and Sons, Ltd., Cardiff; dimensions, 400ft. by 54ft. 3in. by 28ft. 0¼in.; to carry cargo. Engines, triple-expansion, 25in., 42in., 70in. by 48in. stroke, pressure 200 lb. per square inch; constructed by Central Marine Engine Works of Wm. Gray and Co., Ltd.; trial trip, March 29th.

Saugor, single-screw steamer; built by Harland and Wolff, Ltd., to the order of James Nourse, Ltd., of London; dimensions, 439ft. 6in. by 56ft. by 31ft. 4in.; about 6300 tons gross. Engines, triple-expansion, 26in., 44in. and 74in. by 51in. stroke, pressure 180 lb. per square inch; trial trip, March 29th.

Soreldoc, steamship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Paterson Steam Ships, Ltd., Fort William, Ontario; dimensions, 253ft. long; to carry cargo. Engines, inverted marine type; constructed by the builders; trial trip, March 30th.

Zealandic, twin-screw motor ship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Shaw Savill and Albion Company, Ltd., of London; dimensions, 500ft. long, 11,100 tons deadweight; to carry cargo. Engines, twin reversible single-acting two-stroke Diesel engines of the Wallsend-Sulzer type; constructed by Wallsend Slipway and Engineering Company, Ltd., Wallsend-on-Tyne; trial trip, March 29th.

Sir William H. Raeburn, twin-screw grab hopper dredger; built by Ferguson Brothers (Port-Glasgow), Ltd., to the order of Clyde Navigation Trustees. Engines, two sets compound surface condensing; launch, April 9th.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Birmingham Quarterly Meeting.

THE quarterly meeting of the Midland iron and steel trade, falling as it did in the middle of a week which at many of the works was given over to holidays, was not so well attended as might otherwise have been the case. Considerable interest, however, was evinced in the gathering, for it was looked to to provide an indication of the probable course of trade in the heavy industries of Birmingham and the Midlands over the spring quarter. Conversations on 'Change led one to the opinion that there is every prospect of improving conditions, not only in this area, but throughout the kingdom generally. There was a brighter tone manifest, but it was held that while the trade movement was in the right direction it would be a mistake to regard it as really encouraging. Some good inquiries were in circulation, but there seemed no haste to secure supplies of material. Iron and steelmasters reported that they have better order books than of late, and many of the local foundries are busy on tires, axles, buffers and fittings for rolling stock. The engineering industry, as a whole, has, I gathered, brighter anticipations, though few of its many branches report flourishing conditions. Midland constructional engineers are undoubtedly busier than they have been for some time past, though in this branch the improvement which three months ago was foreseen has proved disappointing. The impoverishment of the British railways reacts on the inland yards, with their circumscribed radius of operations. Concerns in this district have had to adapt themselves not only to exigent forces which have changed the currents of trade, but also to new engineering conditions. The mechanical engineers maintain a fairly good turnover in the aggregate. The position in the machine tool trade is improving but slowly. Electrical engineers are more prosperous than ever, and the electrical engineering works in the Midlands are providing employment for many thousands of hands. It is questionable if they have ever employed so many as at the present time. Motor engineers are speeding up production, and are using large quantities of Midland iron and steel and manufactures thereof. Taken all round, the outlook for the ensuing quarter may be regarded as tolerably good.

Raw Iron.

At the Birmingham quarterly meeting this week consumers of pig iron used every endeavour to force Midland smelters to concede further reductions in the price of foundry pig iron. They have in many instances been buying only in driblets for some months past, in the hope of securing better terms on which to negotiate forward contracts. A little contracting in advance has been done, and nothing has been lost to consumers thereby. Northamptonshire makers at the middle of the quarter took concerted action to keep values up to quoted rates, and prices remained firm until a week or so ago, when to secure much-needed orders some sellers accepted 1s. per ton below the ruling figure. Derbyshire makers have firmly held to their quotations, and the slight improvement in buying recently has lowered stocks, and improved the position of blast-furnacemen. This week there has been little or no call for iron, nearly all the consuming works having been idle, but potential buyers at the quarterly meeting made inquiries for some very large tonnages, indicating an improvement at the consuming works. Smelters would be very glad to book some really large orders, and at the time of writing they were considering the advisability of meeting, in regard to price, those prepared to negotiate bulk contracts. When the market opened Northamptonshire No. 3 foundry iron stood at £2 19s. to £3 per ton; forge, £2 13s. 6d.; Derbyshire foundry, £3 4s. to £3 4s. 6d.; forge, £2 19s.

Steel.

Little business has been done in steel this week, any which may have been in view having been held up until to-day's quarterly meeting. Midland steel works have some reserve of business with which to begin after the holidays, but it will need replenishing early if the mills are to be kept going. Engineers in this area do not appear to be any too well employed, and inquiries are not as numerous as one could wish or as is usual at this time of the year. It was remarked on 'Change in Birmingham to-day that, despite the higher continental prices recently prevailing, the volume of work reaching native mills has been disappointing. It is agreed that there were indications that the proportion of foreign steel being used in building structures was gradually falling. Where this material is persistently used, it is said to be restricted to the smaller sizes, British material being preferred where heavy stresses are involved. What will happen now that continental quotations are again on the decline remains to be seen. Shippers to-day quoted billets from 2in. to 2¼in. at £4 11s. 6d., f.o.b. Antwerp; 2¼in. up to 4in. at £4 9s.; and sheet bars at £4 11s. 6d. The cost of carriage in each case works out at from 18s. to 19s. a ton. English billets and sheet bars were priced at about £6. Small rolled bars sold from £7 5s. upwards. Staffordshire hoops were named £10 10s. at works. Plate mills complain of poorness of demand, despite what they claim to be very reasonable prices. The steel trade in the Midlands is in need of a filip.

Galvanised Sheets.

Midland sheet mills for the most part resumed work at mid-week, there being sufficient work on hand to make that course desirable. The current quotation for 24 gauge galvanised corrugated sheets is £13 2s. 6d. to £13 5s. Black sheets are in improving request, while lighter gauge sheets for export sell fairly freely.

Finished Iron.

Most of the Black Country wrought iron mills are still idle, manufacturers having given their employees a full week's holiday. In few cases is there any substantial reserve of work to be carried forward, and millowners hope that there will be a sufficient accumulation of orders during the interval, especially as the quarterly meeting falls during that time, to permit of a fairly general resumption. The price of Staffordshire iron has been much steadier lately, and there are hopes that a recovery may now set in. The Staffordshire mills are fairly active, the chief demand being for best iron and gas strip for the manufacture of tubes. The importation, however, of finished tubes continues a disquieting feature in the Wednesbury district. The recent ascertainment of the Wages Board is encouraging to the extent that output shows a substantial increase during January and February, compared with the preceding two months. Values have been almost stationary, the average net selling price having fluctuated to the extent of only about 1s. a ton in a downward direction. Marked bars were quoted this week at £12 10s., Crown bars have a wide range of from £9 5s. to £10 and £10 5s. Lancashire and other outside makers continue to compete in this market, and do not hesitate to bring their prices down to customers' requirements. Little Staffordshire Crown iron is being sold. Belgian No. 4 iron, described as "best best," has advanced 3s. 6d. per ton, being now named £7 11s. 6d. delivered in the Midlands, and importers claim to have sold a fair quantity of this material. Nut and bolt and fencing iron is still quoted £9, but offers of supplies at £8 17s. 6d. are none too readily accepted. Continental material, which answers the purpose very well, is procurable at low rates, and so commands the market. Wrought iron gas tube strip sells well at £11 10s., though some of the Staffordshire works are not as busy as they were.

Bolts and Nuts.

The nut and bolt industry in this area continues in a fairly satisfactory condition, many of the works being well employed. It is regrettable that so little native material is being consumed in the works and that Belgian raw material is being used in its place. The more is this so when one contemplates the position in the light of the recent remarks of Mr. G. Wiley, the well-known Black Country manufacturer of nuts and bolts, who asserted that "the bolt and nut industry is one that calls for the highest skill and perfection. Lives depend upon the quality of the bolts and nuts manufactured for motor cars, steamships and aeroplanes." During the last forty or fifty years the bolt and nut trade had been spoken of as being "down and out," but it seemed to have a wonderful power of recovery, and he believed that it was in as healthy a condition as it could be. It was quite true some firms were rather quiet, but it was also true that every week there were three times as many bolts and nuts being turned out as there were twenty years go. Staffordshire wrought iron for nut and bolt making is so expensive when compared with foreign material that manufacturers contend they cannot possibly utilise it except in cases where the cost of the finished article is subservient to quality. To compete in the world's market prices must be extremely keen, and bolts and nuts made of Staffordshire iron could not be sold in competition with those made from continental iron. It is noticeable of late, however, that there has been a falling off in the use of Belgian No. 3 iron in the Black Country nut and bolt works. This is accountable for by the fact that many makers are now making increased use of steel in their manufacture.

Pressed Steel Factory.

Steelway, Ltd., of Queensgate Works, Monmore Green, has just constructed a new factory for the production of pressed steel goods, principally patented steel flooring for power stations, factories, workshops, and ships, on a site at Bilston-road, Wolverhampton. The new factory, which is now being fitted with machinery, will, it is anticipated, commence production in the near future. As far as Wolverhampton is concerned, this is an entirely new development, for amongst the many steel products of the firm will be the manufacture of stairways for ships. Hitherto, I am given to understand, it has not been possible to use steel on ships for stairways because of its weight. That difficulty has now been overcome by a patented design, which offers many possibilities of development. The flooring used for the steps will be exceptionally light, yet much stronger and more durable than cast iron. In addition, it is non-slip. The same constructional detail is used for flooring purposes, and, as it allows light to penetrate, its advantages are obvious. Other products to be manufactured by the firm are fencing and gates, industrial trucks and trailers, fire-escapes, fireproof doors, lathe parts—some of which previously were of cast iron—tanks and vats, racks and shelving, safe linings, barrows and steel channels.

Furnace Facing Manufacture.

I am given to understand that an influential London business man, with big interests both at home and abroad, in conjunction with two Black Country gentlemen, proposes in the near future to establish on extensive lines a factory for the manufacture of sanitary ware and special facing material for furnace work, in Willenhall, South Staffordshire. Negotiations are in progress, and on the completion of these the work of laying down plant and erecting the factory will be begun. The proximity of beds of fire-clay, stated, after searching tests, to be some of the finest in the country, and of workable granite of a tremendous thickness, which will last for many years, was a circumstance said greatly to influence the choice of Willenhall for the works. Moreover, there are many cinder mounds in the neighbourhood, the contents of which, it is stated, will be utilised in the works.

Birmingham–Bristol Waterway.

Birmingham, in view of its distance from the sea, is more dependent on transport than any other centre in England. It is vital, therefore, to the city to have the cheapest possible transport for goods coming in and for the dispatch of finished goods. The importance to traders of maintaining a "free" waterway between Birmingham and the sea at Bristol for the purpose of keeping down railway and transport rates should therefore be obvious to all. Last year there was a threat that the Worcester and Birmingham Canal would be closed. It was not paying its way, and the Sharpness Company said that it could not continue to operate at a loss. There is now, however, every indication that stoppage will be avoided, and the waterway remain open. A scheme has been arranged for guaranteeing the Worcester and Birmingham Canal against loss by a fund of £2000 per annum for the next five years. This scheme has been arranged in agreement with the owners of the canal and the Sharpness New Docks Company, with whom the guarantors will form a small committee to act in operating the waterway. Birmingham's share of the guarantee is £1400 and Bristol's £600. The Bristol traders have raised their quota, and £865 has been promised so far of the sum required from Birmingham to carry through the scheme. An appeal for the remaining £600 has been made, and, considering the vital importance of keeping open this effective waterway as a bargaining factor, and because of its effect on all transport rates in Birmingham, there should be no question about its being forthcoming. The cost of keeping the waterway open is little, but the possible effect of its closure on rates might go into tens of thousands of pounds.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Electrical Plant from Belgium.

STRONG support for a recommendation of the Electricity Committee to the effect that a tender submitted by a Belgian firm of electrical engineers for the supply of a 2500 kW converter plant should be accepted was forthcoming at the last meeting of the Manchester City Council. The chairman of the Committee explained that the price quoted by the Belgian firm was £5650, and the lowest tender received from a British firm was nearly £8000. Another member of the Committee stated that whilst they were anxious to accept British tenders wherever practicable, they had also to protect the interests of the ratepayers, and in the electrical engineering industry there was a stronger assurance for the upkeep of fictitious prices than in any other. If they invited foreign manufacturers to compete for the orders they ought not to reject their tenders unreasonably. The Belgian firm in question, it was pointed out, actually purchased from this country every month more than £9000 worth of British materials for the manufacture of its products. Opposition to the acceptance of the Electricity Committee's recommendation was based on the low rates of wages paid to Belgian workmen as compared with those in this country and on the large volume of unemployment here.

Gasworks Plant for Southport.

A Ministry of Health inquiry has been held at Southport into an unopposed application by the Corporation of the town for power to borrow £14,000 for the purchase of additional plant for the gasworks. In support of the application it was urged that during the last twenty-three years the output of the gas undertaking had been doubled, but that in the same period the capital had only increased from £198,000 to £200,000.

Non-ferrous Metals.

Except in the case of tin the past week has witnessed little in the way of price fluctuations on the non-ferrous metals market. Due allowance being made for the intervention of the holidays the demand both for standard and refined descriptions of copper has been on a fairly satisfactory scale, and quotations have been steady to firm in all sections. In respect to tin, however, the firmness of the two preceding weeks has been followed by a weak spell, more particularly on the resumption this week. Not the whole of the previous gain has been wiped out, although a substantial proportion has, and values current at the time of writing are not very much higher than they were before the last advance. The explanation of this renewed weakness lies primarily in a change in the statistical position of the market from that recently ruling, as a result of an addition to stocks of the metal in this country, and of bigger supplies on offer. Lead has about maintained its comparative steadiness of the past three weeks, and spelter, also, shows little if any change in prices on balance. In both cases, however, the demand has been very moderate.

Iron.

The past week has been a poor one from the point of view of actual business done in pig iron on this market. Generally speaking, the stoppage of the foundries in the Lancashire district was very brief, but the resumption of the market on Tuesday attracted relatively few people, and business was one of the things that was not seriously discussed. This quietness is, of course, purely seasonal, and is not expected to extend beyond the current week, at all events, to the same degree. Notwithstanding the fact that there has been no very pronounced buying movement in progress during the past one or two months, some of the leading Derbyshire makers of pig iron have met with a quietly steady demand in this part of the country, and in the aggregate have sold what they describe as a not unsatisfactory tonnage. Quotations for Midland brands up to the time of writing have shown little alteration from those last reported, but an advance from the present relatively low levels in the near future would not be wholly unexpected. For delivery Manchester or equal distance Derbyshire makers are quoting from 72s. to 72s. 6d. per ton, and Staffordshire at about 71s. 6d.; Middlesbrough keeping steady at 79s.; Scottish at 87s. 6d. to 90s.; and hematite at 84s. 6d. Lancashire Crown bars are steady at £10, and seconds at £9 10s., but the demand for these materials is on a very quiet scale.

Steel.

The movement of steel into consumption this week has been slow, but here again the cause is largely

seasonal, specifications being delayed as a result of the holidays. Although there has been a slackening off in inquiries in the constructional engineering branch with a consequent less certain outlook, several important contracts under execution or about to be commenced are held by local firms. The demand for steel this week has been slow in all departments, but so far as prices are concerned, the position generally seems to be quite steady, and little change has taken place. Ship and tank plates continue to be quoted at £8 12s. 6d, joists and sections at £7 17s. 6d., and bars, 3in. and upwards, £8 17s. 6d., all subject to the rebate allowances to qualified consumers. Occasional low offers of small bars re-rolled from imported semi-finished materials continue to be reported, but the more general range for these goods is from £7 10s. to £7 12s. 6d. per ton. With regard to boiler-plates, acid varieties are quoted at from £10 to £10 5s. per ton, according to quantity, and basic plates at about £9 15s. per ton. Only minor transactions have taken place in continental steel products on this market, and values in this section are nominally unchanged from those I quoted last week.

BARROW-IN-FURNESS.

Hematite.

The hematite pig iron trade is still marking time. In consequence of the steel works at Barrow being closed down, iron from two furnaces is going into stock. This is practically the case also at Workington, where the steel works are not expected to start on rails, &c., until the middle of the month. This continuous production, despite the stoppages in the steel departments, suggests that there is some expectation of the demand for pig iron improving, but it is too early at the moment to say definitely what will happen yet. In some places where iron has not been produced for some time, stocks are getting low, and there is some talk of one or two more furnaces being put into blast. Certainly if stocks are cleared, furnaces will go in probably at Ulverston, and perhaps at Cleator Moor. It is really a matter of time. Throughout this quiet period, it is worthy of remark that the Millom Company has had three furnaces going; in fact, just as one firm put out a furnace, it increased its number of furnaces to three. The iron ore trade is quiet, the local demand is moderate, and business in better qualities, outside the district, is not very considerable. At Hodbarrow, a new shaft is being sunk, and developments may be expected in that direction. Foreign ores are being imported in restricted quantities. In the steel departments no rails are being turned out at present. In Barrow the holidays continue. At Workington it is expected that all departments will be engaged within a fortnight. The steel market is quiet, and orders are difficult to obtain. It is not known at the moment when Barrow will restart.

SHEFFIELD.

(From our own Correspondent.)

A Steel Trade Review.

THE Easter holiday stoppage in Sheffield and district was of normal duration, which means that work has been carried on for about half of the present week. Conditions in the various branches of the steel trade remain much as previously reported. So far as the heavy side is concerned, Sheffield appears to be gaining less advantage from the higher prices of continental steel than some other districts. The inquiries for basic steel billets are on a disappointingly small scale, and although production has been reduced, the tonnage booked for delivery during the next few weeks is hardly sufficient to absorb it. In better class steels the position is somewhat better. A moderate amount of railway work is on hand, but the specifications from British railway companies are on the basis of minimum requirements. An increased amount of work is being got out of locomotive and wagon stock, with the result that expenditure on new construction is kept down. The requirements of electrical engineering are still proving very valuable to Sheffield, and stainless steels continue to progress, but the demands of the automobile industry, although large, are not up to recent averages. On the whole, work is maintaining the standard of the last few months, but it is unequally distributed, and while some firms are well employed, there are many instances to the contrary.

Competition in Tool Steel.

There is an increasing home demand for the best tool steels and engineers' small tools, owing to the expansion of some branches of engineering, and the present consumption is larger than has been experienced for a considerable time. In export markets, however, only a poor trade is being done, and it shows little sign of improvement. Makers in Czecho-Slovakia, and to a smaller extent in the Saar, are strong competitors of Sheffield in most of the foreign and colonial markets. Underselling is very keen, and business difficult to get. So far as chemical specification goes, the foreign material is of similar quality to that of Sheffield, but for special and important engineering operations foreign users frequently buy the most expensive Sheffield brands. The wide difference in prices is largely accounted for by cheap electrical power on the Continent. With a view to combating the competition, the Association price of 14 per cent. tungsten steel in this country has been reduced from 2s. 3d. to 2s. per pound.

Cutlery and Plate.

There is little change to report in these trades, which have shown a considerable falling off since the improved conditions of the early part of the year, and now present few satisfactory features. The demand for best quality goods is especially poor, and this is accounted for in some quarters by the pressure for income-tax payments. At the same time the call for cheaper goods, although still very large, has declined lately. Not many orders have been placed recently for cutlery and plated goods for coupon distribution. The War Office is again inviting tenders for safety razors and blades, 40,000 of each being wanted. On the three previous occasions when contracts were placed by the Department they were secured by Gillettes, but Sheffield firms are endeavouring to obtain the work.

A Full-time Colliery.

In these days of coal trade depression, it is pleasing to learn of collieries that are working full time. Thorne, one of the newest pits in the Doncaster area, is among the few that are in this happy position. No. 2 shaft has been completed, and in use for some time, and now, after the Easter holidays, No. 1 shaft has been brought into use, and will enable the colliery to increase its output considerably. This will eventually give employment to many more miners, but there is not likely to be any remarkable addition to the number of employees for the time being.

A Huge Blasting Operation.

Blasting on a large scale is fairly common in the limestone quarrying industry of Derbyshire, but an operation which brings down 70,000 tons of rock is exceptional, even for that district. Such an operation was carried out on Sunday at the Buxton Lime Firm Company's Longside Quarry, Peak Dale, near Buxton. The whole face of a cliff was brought down. The preparatory work, which lasted several weeks, included small blasting operations at the base of the cliff, by means of which a chamber was made inside the rock. Some 5½ tons of gunpowder were placed inside this chamber, which was then securely blocked up by means of concrete walls, and a fuse wire laid. In addition, seven holes, 70ft. in depth, were drilled into the cliff from the top, and in them one ton of gelignite was deposited, and connected with fuses. The powder and gelignite were exploded at the same time by electricity. The use of a high explosive as well as gunpowder was a new experiment for this occasion. The operation was successfully carried out. It is estimated that it will take a month to get all the stone trucked.

Batley's New Reservoir.

The Corporation of Batley is constructing a new reservoir in the Holme Valley, on which, up to the end of the last financial year, £495,380 had been expended. The original Parliamentary estimate of the total cost was about £500,000, but it seems probable that the actual expenditure will exceed that mark by some £120,000. In a statement by Alderman J. E. Oldroyd, chairman of the Waterworks Committee, it is pointed out that the accepted tenders of £477,599, work by direct labour costing £18,550, and an allowance for contingencies, give a total of £57,729 more than the Parliamentary estimate, while excess expenditure since incurred, of about £64,000, brings the total up to date to £621,593. In explanation of the increase, it is pointed out that the contract for the reservoir provided for the rehousing of displaced population, and the reconditioning of the embankments of two of the town's existing reservoirs, and that neither of those items was covered by the Parliamentary estimate. The consulting engineer also emphasises that construction of a reservoir in the Holme Valley "has never been regarded as other than a difficult operation, of which the ultimate cost, however carefully computed, could not be accurately foreseen."

Gas and Electricity.

Doncaster Town Council is expecting to obtain a contract for the bulk supply of gas for the London and North-Eastern Railway Company's works in the town for a period of ten years, and has decided, in that event, to ask the Ministry of Health to sanction a loan of £10,000 for extensions to the gasworks. The use of electricity is to be greatly extended in the Peak district of Derbyshire. It is expected that by the autumn of this year current will be available for a number of places, including Hathersage, Grindleford, Froggatt, Eyam, Baslow, Calver and Stoney Middleton, and that the service will probably be extended to Tideswell. The Nottinghamshire and Derbyshire Electric Power Company will supply the electricity from its station at Spondon, where additional generating plant is to be laid down, capable of increasing the present capacity of 39,000 kW by 25,000 kW. The transmission line has now been carried as far as Baslow. The Stoke quarries at Grindleford are to be completely electrified, this motive power to be adopted for the cranes, stone-sawing, crushing and drilling machines; and the electric drive is also to be installed by several shoe factories in the district.

American Typewriters for Sheffield.

A good deal of comment has been passed on the action of the Sheffield Corporation in deciding, on the recommendation of the Finance Committee, to give a contract for the supply of typewriters, extending over a period of five years, to the Underwood Company. A month ago it was stated that English makers of typewriters had an opportunity of tendering, but it now transpires that this was not the case. Tenders were invited only from the makers of the three machines most in use in Corporation departments, and these machines are all American. On the one hand, it is stated that the contract will result in a substantial saving to the ratepayers, and on the other that English makers were prepared to quote as low a price as any American firm, in addition to which there is the obvious consideration that the acceptance of an English contract would mean work for Englishmen and Sheffielders. However, an amendment in the Council, to refer the matter back for further consideration, was defeated.

NORTH OF ENGLAND.

(From our own Correspondent.)

Shipbuilding Outlook.

THE future of the shipbuilding industry on the North-East Coast is again causing some anxiety. Inquiries for new ships have never been numerous this year, and recently the prospects for additional work dropped considerably. Shipbuilders, who are compelled to look well ahead, are already showing some anxiety in regard to work in the yards after two or three more months, and the outlook is not cheerful for several firms, which are rapidly getting through the work they started the year with. When Swan, Hunter and Wigham Richardson can build seven Canadian Lakes steamers in a little over two months, Palmers an oil tanker in fifty-two working days, and Hawthorn, Leslie the huge Singapore Dock in ten months, it will be readily realised that there must be a continual flow of new work even to keep the berths now in use occupied. Last month thirteen vessels were launched on the North-East Coast in one week, and only two orders were received in compensation, these being only vessels of moderate size, the contracts for which went to Wear shipbuilders. On the Tees last week Smith's Dock Company established a record by carrying out the trials of a new ship and two launches of new vessels. The contract for the three vessels, which are to augment a fleet of Lake steamers in Canada, has been expeditiously carried out, as work on the first one only commenced in November last year, and since that time all the vessels have been completed. Work, however, has decreased to such an extent in some yards that men have been dispensed with. In the circumstances, therefore, it is satisfactory to learn that there are indications of a slight revival, and that shipbuilders are receiving more inquiries from brokers and shipowners regarding new tonnage. Inquiries do not necessarily mean orders, but shipbuilders are always hopeful, and do their utmost to secure business, even though there is little margin of profit on some contracts nowadays.

Cleveland Iron Trade.

With makers still quoting bedrock prices and the terms on the Continent hardening, the position of the Cleveland pig iron trade is very favourable to expansion after the holiday influences have worn off. Stocks are all but exhausted, output on the present restricted basis is being immediately absorbed, and prospects of this feature remaining as a steadying influence on the market are unmistakable. While demand continues on quiet lines, makers have only to indicate the cost of raw materials consumed per ton of pig iron to demonstrate the futility of consumers hanging off while anticipating lower terms. The situation abroad is peculiar and somewhat difficult to sum up. Though an early return of formidable continental competition is not greatly feared, some apprehension is felt that rather more use may be made shortly of commodities from overseas. As yet, however, quotations for many descriptions of foreign iron and steel are not attractive, and it is difficult to see how continental manufacturers can further materially reduce their prices. Cleveland iron prices are firmly maintained, No. 1 foundry being 68s. 6d.; No. 3 G.M.B., 66s.; No. 4 foundry, 65s.; and No. 4 forge, 64s. 6d. It is reported that for continental iron claimed to be equal in quality to No. 3 Cleveland 65s. f.o.b. Antwerp is named, and the freight to the North-East Coast makes the delivery price here prohibitive, while the price concession which Cleveland ironmasters grant to pig iron consumers beyond the Tweed promises to continue to prevent resumption of extensive use of foreign material in Scotland.

Hematite Pig Iron.

There is an improved tone in the East Coast hematite pig iron trade, but values, while tending upward, as the result of a little better home and continental buying, are not quotably advanced, and are substantially below cost of production. Makers are carrying considerable stocks, which are still being steadily augmented. Prices vary a good deal, but nominally recognised market rates remain on the basis of mixed numbers at 70s.

Ironmaking Materials.

Very little new business is passing in the foreign ore trade, but sellers take a firm stand in the confident belief that supplies will be short. Best Rubio ore is put at 22s. c.i.f. Tees. There does not appear to be much hope of an early termination of the strike of ore miners in Sweden, and imports from that country threaten to cease in the very near future. Deliveries have been coming forward fairly well from Narvick, but stocks there are stated to be now virtually exhausted. Consumers in this district have moderate supplies on hand, which, however, will speedily be absorbed. Durham blast-furnace coke is slow of demand, and 18s. is a full quotation for good average qualities delivered to works in this area.

Manufactured Iron and Steel.

In certain branches of the manufactured iron and steel trade the need for orders is becoming rather more urgent, but in other sections substantial contracts are in hand, which will ensure active working conditions for some months ahead. Of late, sales have been on only a limited scale, but hope of a gradual trade development survives. The North-East Coast still remains Britain's greatest iron and steel-producing area. During the first two months of the current year 175,500 tons of pig iron and 170,000 tons of steel were produced in the district.

The Coal Trade.

There is very little movement in the Northern coal trade. Output, of course, has been interrupted by the holidays and supplies on the market are likely to be very limited for a week or two. Sellers, therefore, are not keen to dispose of the small surpluses, and consequently indicate top values. Little attempt is made to go closely into forward business, the inclination being to hold off. Fitters report fairly good bookings over the remainder of the month. Northumberland steams, large and small, keep to recent stronger figures, and all gas coals are firm. Specials are in sustained demand, and seconds are receiving increased support. Coking fuel is healthier in tone, and sales have been recorded at 14s., with 13s. 9d. a well-established figure. Bunkers are without new features, best brands being in most request at 14s. 6d. to 15s. 6d. Good average sorts are 13s. 3d. to 13s. 9d. There is a fairly steady demand for gas coke for April shipment, and transactions are being steadily booked at 20s. for best

grades. Patent oven cokes for prompt meet a sustained demand, and are rather firmer at 17s. to 18s., with special qualities at 23s. to 25s., and beehive at 24s. to 27s.

Iron Trade Wages.

Blast-furnacemen employed at North-East Coast ironworks have suffered another reduction in wages. The average net selling price of No. 3 Cleveland pig iron for the past quarter has been certified at 63s. 0·23d., compared with 64s. 7·04d. for the previous quarter, and under the sliding scale arrangement blast-furnacemen's wages are reduced by 1·5 per cent., bringing them down to 9 per cent. above the standard.

SCOTLAND.

(From our own Correspondent.)

Uncertain Outlook.

THE general outlook in steel, iron and coal circles is still most uncertain. Export business is very patchy and restricted, and home markets are far from active. Steel and iron producers are apprehensive of a rise in the price of fuel, consequent on the institution of the scheme to stabilise the coal industry, particularly in view of the reactionary tendency of foreign prices of competitive material. Furthermore, it is difficult to comprehend how the curtailment of coal production is going to stimulate the export coal trade on which certain East of Scotland districts chiefly depend. Meanwhile, business generally is becoming more and more difficult, and prospects more obscure.

Steel and Iron.

Business in steel and iron continues mainly on a hand-to-mouth basis, and few, if any, of the works are fully employed. Orders for shipbuilding materials are somewhat better, but specifications for structural materials are far from satisfactory. Heavy steel sheets are no more than moderately busy, and although the thin varieties are somewhat better off, the total turnover is not too encouraging. Galvanised sheets, however, are finding a better outlet. Bar iron and re-rolled steel bars are still suffering from keen continental competition. Some cheap offerings of Belgian bars have recently been made. Welded tubes are comparatively busy. Prices are all unchanged.

Pig Iron.

The Scottish pig iron market remains firm by virtue of dearer prices of ore and a drop in imports, actual business being small.

Exports and Imports.

During the past week 3700 tons of iron ore and 1000 tons of iron were unloaded at Glasgow docks, and during the same period 3000 tons of steel and iron were shipped abroad. An improvement in shipments of tubes, structural material and machinery was reported.

Coal.

The restriction of outputs has already had an effect on the export branch of the coal trade. For some time past exporters have been chary of discounting colliery quotations, and are now even less inclined to do so. Consequently, business is almost entirely confined to small prompt lots to cover sales against contracts. Forward transactions are practically impossible. Collieries are inclined to quote higher prices, and these also mitigate against land sales. Many concerns anticipating higher values have already arranged deliveries, while others are inclined to "wait and see," rather than pay the advances asked. Meanwhile business for export or land sale is meagre.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

INACTIVE conditions prevail in all sections of the coal trade, which is no more than what can be expected, in view of the holidays and their prejudicial effect upon operations. Work was resumed at the docks on Tuesday morning, but was suspended at mid-day, while so far as the miners were concerned, the night men went in on Tuesday night. The position regarding business was extremely quiet, and it is doubtful whether there will be much activity before next week, and even then it looks as if the conditions will be on the dull side, as the fresh inquiry for coals continues to be very restricted. Hopes were entertained that the arrival of tonnage over the holidays would go a long way to make up for the exodus of steamers at the end of last week, but the situation in this respect was somewhat disappointing, as on Tuesday morning the returns showed that there were thirty idle loading appliances at the various docks, which on the face of it means that there cannot be a ready outlet for the considerable quantities of coals which are available for shipment. Altogether, the outlook causes no little amount of apprehension, as indications do not point to an improvement in the general position. Chartering operations have of late fallen off to an appreciable extent, and even allowing for the decline in output, owing to the holidays, it is to be feared that a considerable number of collieries will find it difficult to work with regularity as the result of the paucity of the demand. Not only is the inquiry for current supplies on the dull side, but there is very little activity in respect of coals over a period. The Norte Railways of Spain have purchased 30,000 tons of large coals for delivery over about three months, and news is awaited regarding the placing of a contract for about 60,000 tons of best Admiralty large coals for one of the leading Italian shipping companies to be delivered over the next six months.

Docks Traffic.

According to the returns of the Great Western Railway Company, there was an improvement in trade for the four weeks ended March 18th, as compared with the figures for the previous month. The returns are compiled in respect of the six docks, viz., Cardiff, Swansea, Newport, Barry, Port Talbot and Penarth. Imports were not quite so good, but the loss in this department was more than made up for by the increase in exports, chiefly of coal and coke. For the four weeks ended March 18th, imports came to 358,770 tons, as against 388,122 tons for the preceding four weeks. Exports, however, totalled 2,559,073 tons, which compared with 2,182,297 tons, the aggregate of imports and exports amounting to 2,917,843 tons, as against 2,570,419 tons, an advance of 347,424 tons. The returns so far this year fall short of the total for last year. Imports and exports together for the period from January 1st to March 18th come to 7,491,807 tons, whereas the figure for the same period in 1927 was 8,182,290 tons. Imports alone were 1,032,387 tons, as against 1,367,054 tons; while exports were 6,459,420 tons, as compared with 6,815,236 tons.

Cardiff and Shipping.

According to a list of the members of the Cardiff District Committee of the Shipping Federation, which has recently been issued, the number of steamers controlled by local companies is 305, of an aggregate gross tonnage of 1,047,172, which, however, compares with 312 vessels, of 1,164,907 gross tons, twelve months ago. The owners of the largest fleet are Foster, Hain and Reed, Ltd., who have forty-two vessels of 198,467 gross tons; while Sir W. R. Smith and Sons come next with a fleet of twenty-seven vessels of 137,884 tons gross; Evan Thomas, Radcliffe and Co., Ltd., have twelve vessels of 62,107 gross tons; and W. J. Tatem, Ltd., have thirteen vessels of 56,800 gross tons.

Current Business.

Operations in coals for prompt loading have been practically at a standstill, as most exporters had made arrangements for the tonnage which they had due immediately after the holidays. Quotations in the circumstances are nominal, apart from which there is some speculation as to what may be the position when the committee dealing with the scheme for the stabilisation of coals has had its meeting on Thursday of this week. Shipments will, of course, make a very poor showing for the past week, owing to the holidays. For the week ended the 5th inst., the total was only 318,597 tons, which compared with 458,123 tons for the preceding week.

Catalogues.

ANDREWS AND CAMERON, Kirkintilloch.—Brochure on sea water evaporators.

JAMES WILEY AND SONS, Ltd., Eagle Works, Darlaston.—March stock list of bolts and nuts.

RUSTON AND HORNSBY, Ltd., Lincoln.—Leaflet on the "Ruston" No. 4 full circle universal excavator.

HADFIELDS LTD., East Hecla Works, Sheffield.—A descriptive pamphlet on Hadfield's special heat-resisting steel.

THE VISCO ENGINEERING COMPANY, Ltd., 162, Grosvenor-road, S.W. 1.—Leaflet 281 on the Visco Beth dust collector.

DAVID WILSON AND CO., 40, Brazenose-street, Manchester.—Folder on the "Fisher" pressure regulator for steam, gas, or air.

MAVOR AND COULSON, Ltd., 47, Broad-street, Mile End, Glasgow.—A booklet dealing with electric shaker conveyors for mines.

SIR W. H. BAILEY AND CO., Ltd., Salford, Manchester.—Catalogue S 3127, describing "Davidson" vertical steam pumps.

SOAG MACHINE TOOLS, Ltd., 45, Horseferry-road, S.W. 1.—Catalogue 1927–28, giving lists of the machine tools stocked by the firm.

THE MOSS GEAR COMPANY, Ltd., Crown Works, Birmingham.—A booklet dealing with designing and generating worm reduction gearing.

HANS RENOLD, Ltd., Didsbury, Manchester.—A booklet of 250 pages giving prices, sizes and specifications of all types of chain drives.

KIRKSTALL FORGE, Ltd., Kirkstall, Leeds.—Booklet giving the firm's history, equipment and specifications of the various steels supplied.

PRIESTMAN BROTHERS, Ltd., 28, Victoria-street, S.W. 1.—A folder graphically describing the Priestman combined grab hopper dredger.

F. BRADY AND CO., Ltd., Glasgow.—Catalogue illustrating and describing various structural steel work contracts carried out by the firm.

J. H. SANKEY AND SON, Ltd., Essex Wharf, Canning Town, E. 16.—A leaflet describing the various grades of "Pyruma" plastic fire cement.

W. G. ALLEN AND SONS (TIPTON), Ltd., Princes End, Tipton.—An illustrated catalogue of electrically welded and riveted steel plate and pipe work.

EDGAR ALLEN AND CO., Ltd., Imperial Steel Works, Sheffield.—A pamphlet introducing the firm's new high-speed tool steel known as "Stag Major."

HEAD, WRIGHTSON AND CO., Limited, Norton-road, Stockton-on-Tees.—Specifications of the elevators, belt conveyors and screens made by the firm.

AUTOMATIC AND ELECTRIC FURNACES, Ltd., North-road, Holloway, N. 7.—A catalogue on the "Wild-Barfield" electro-magnetic hardening furnace.

RANSOMES AND RAPIER, Ltd., Ipswich.—Publication No. 201, describing "Ransome" tilting drum mixers for concrete, chemicals, tar-macadam, &c.

THE FERRO-ARC WELDING COMPANY, Ltd., 12, Grosvenor-gardens, S.W. 1.—Results of tests on the Ferro-arc system of welding with Ferro-arc electrodes.

THE GENERAL CHEMICAL AND PHARMACEUTICAL COMPANY, Ltd., Willesden, N.W. 10.—A price list of "Judex" analytical reagents and laboratory chemicals.

J. COLLIS AND SONS, Ltd., 48, Regent-square, W.C. 1.—List No. 40, introducing the latest models of Collis trucks using the platform system for handling goods.

J. DAMPNEY AND CO., Ltd., 87, Bishopsgate, E.C. 2.—A booklet entitled "Power and Still More Power," dealing with "Apexior" compound for boiler tubes.

STERNS LTD., Royal London House, Finsbury-square, E.C. 2.—Booklet showing how to increase the output of the machine shop by using the right tools and coolants.

LEDWARD AND BECKETT, Ltd., Parliament Mansions, Orchard-street, S.W. 1.—Pamphlet illustrating several patented mechanical water screens of the rotary and the band type.

SMITH BROTHERS AND CO. (Hyson), Ltd., Hyson Green Works, Nottingham.—Brochure entitled "The 80th Milestone," describing the firm's growth during the last eighty years.

BRITISH ROPES, Ltd., 32, Cavendish-square, W. 1.—A pamphlet showing the uses to which British ropes are being put in the work of extending London's underground railways.

RUTHS STEAM ACCUMULATORS, Ltd., Africa House, Kingsway, W.C. 2.—A brochure entitled "Steam Storage," dealing in detail with the Ruth steam accumulator in industrial plants.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., Wharf-road, City-road, N. 1.—Particulars of "Pyromic," a high-temperature electrical resistance alloy.

WATTS, FINCHAM AND CO., Ltd., 22, Billiter-street, E.C. 3.—Folder containing a list of the goods stocked by the firm and particulars of "Wefco" specialities which they manufacture.

LACY-HULBERT AND CO., Ltd., Boreas Works, Beddington, Croydon.—List S 1, giving particulars of the "Boreas" paraffin spray gun for cleaning motor car engines and other machinery.

BELL'S POILITE AND EVERITE COMPANY, Ltd., Asbestos House, Southwark-street, S.E. 1.—A booklet entitled "An Old Friend with a New Face," introducing a new form of Poilite for decorative purposes.

THE GLACIER METAL COMPANY, Ltd., Ealing-road, Alperton, Middlesex.—A brochure dealing in detail with the firm's products, which also gives its history, equipment and some notable work carried out.

THE TUNGSTONE ACCUMULATOR COMPANY, Ltd., 3, St. Bride's House, Salisbury-court, E.C. 4.—A catalogue giving full particulars of Tungstone batteries for central stations, works and for house lighting.

ARTHUR ROSS, HOTCHKISS AND CO., Ltd., 1, Glengall-road, Old Kent-road, London, S.E. 15.—Booklet entitled "A Chat on Water," introducing the "Ross" method of water treatment and the "Hotchkiss" Circulator.

FARRAR BOILERWORKS, Ltd., Newark-on-Trent.—Catalogue describing the firm's manufactures, which include boilers of all types, air receivers and tanks, riveted gas and water mains, chemical and gasworks plant, &c.

DOWDINGS' MACHINE TOOL COMPANY, Ltd., 38, Albert Embankment, S.E. 11.—A booklet on patented spiral bevel gear generators as made by Messrs. Dowding's principals, the Oerlikon Machine Tool Works, Switzerland.

LIPTAK FURNACE ARCHES, Ltd., 38, Victoria-street, S.W. 1.—Booklet describing in detail the "Liptak" permanent flat suspended furnace arches, double suspension arches with renewable blocks, and the "Bigelow" suspended furnace wall.

MERRYWEATHER AND SONS, Ltd., Greenwich-road, S.E. 10.—A pamphlet giving particulars of "Fire Suds" equipment for the protection of oil depots, motor ships and oil-fired steamers; also describing "Mefisto" flame-resisting clothing for fire service.

J. PARKINSON AND SON, Shipley.—Catalogue GG 10 dealing in detail with plain and universal milling machines; catalogue GG 12 of gear planing machines, sharpening machines for gear-planer cutters, rack-cutting machines, gear-testing jigs, and gear-running machines.

MARSHALL, SONS AND CO., Ltd., Gainsborough.—Publication 1793, describing portable and semi-portable steam engines, mounted on "Britannia" boilers; also Publication No. 1795 on high-grade two-cycle oil engines for pumping, electrical, industrial, and other services.

FESCOL LTD., 101, Grosvenor-road, S.W. 1.—Brochure dealing in detail with the "Fescol" process of rebuilding worn mechanical parts by the deposition of nickel, copper, chromium, &c., to any reasonable thickness; the process is also used for protection against corrosion and erosion.

ROYAL SOCIETY OF ARTS: COMPETITION OF INDUSTRIAL DESIGNS, 1928.—By permission of the Board of Governors of the Imperial Institute, the public exhibition of works sent in for this year's Royal Society of Arts' Competition of Industrial Designs will be held in the Exhibition Pavilion of the Imperial Institute, South Kensington, S.W. Full particulars of the scholarships and prizes offered in connection with the Competition can be obtained from the Secretary of the Royal Society of Arts, Adelphi, W.C. 2. Applications for forms of entry, labels, and instructions must be sent to the Secretary of the Society between May 1st and May 12th. The designs entered for the Competition are to be forwarded to the Imperial College of Science and Technology, Imperial Institute-road, South Kensington, S.W., between June 18th and June 20th, and after the judging, which takes place in July, the accepted designs will be on view at the Imperial Institute from August 4th to September 1st (Sundays included).

FARADAY HOUSE ENTRANCE SCHOLARSHIPS AND EXHIBITIONS.—As a result of the entrance scholarship examination held at Faraday House Electrical Engineering College on April 3rd, 4th and 5th, the following awards have been made by the Governors of the College:—(*a*) Ian C. Campbell, Ilkley Grammar School, the "Faraday" Scholarship of 50 guineas per annum, tenable for two years in college and one year in works; (*b*) William E. Walls, Cheadle Hulme Secondary School, the "Maxwell" Scholarship of 50 guineas per annum; (*c*) Eric H. Wolff, University College School, London, an Exhibition of 30 guineas per annum; (*d*) Norman H. Codling, Leys School, Cambridge, an Exhibition of 30 guineas per annum; (*e*) Harry M. Gale, Shaftesbury Grammar School, an Exhibition of 30 guineas per annum; (*f*) Gordon C. Maynard, Alleyn's School, Dulwich, an Exhibition of 20 guineas per annum; and (*g*) Norman H. Bentley, Colne Secondary School, an Exhibition of 20 guineas per annum. Exhibitions (*b*) to (*g*) inclusive are all tenable for one year in college and one year in works.

BUSK STUDENTSHIP IN AERONAUTICS.—The Busk Studentship in Aeronautics has been established in memory of Edward Teshmaker Busk, who in 1914 lost his life while flying an experimental aeroplane. The Trustees hope to make an appointment towards the beginning of July next. The Studentship is of the value of about £150, tenable for one year from October 1st; but a student may be re-appointed on the same terms for a second year. It is open to any man or woman being a British subject and of British descent who has not attained the age of twenty-five years on October 1st next. The object of the Studentship is to enable the holder to engage in research or preparation for research in aeronautics and specially in those subjects such as stability problems, meteorological questions bearing on flight, or the investigation of gusts, treated either experimentally or mathematically, in which Edward Busk was specially interested. Forms of application for the Studentship can be obtained from Professor B. Melvill Jones, Engineering Laboratory, Cambridge, and must be filled up and returned to him not later than May 12th next.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
(1) Native	19/- to 21/-
(1) Spanish	19/- to 21/-
(1) N. African	19/- to 21/-
N.E. Coast—	
Native	18/- to 21/-
Foreign (c.i.f.)	22/6

PIG IRON.

	Home. £ s. d	Export. £ s. d.
(2) Scotland—		
Hematite	3 14 0	—
No. 1 Foundry	3 15 0 to 3 16 0	—
No. 3 Foundry	3 10 0 to 3 11 0	—
N.E. Coast—		
Hematite Mixed Nos.	3 10 0	3 10 0
No. 1	3 10 6	3 10 6
Cleveland—		
No. 1	3 8 6	3 8 6
Silicious Iron	3 8 6	3 8 6
No. 3 G.M.B.	3 6 0	3 6 0
No. 4 Foundry	3 5 0	3 5 0
No. 4 Forge	3 4 6	3 4 6
Mottled	3 4 0	3 4 0
White	3 4 0	3 4 0
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	—	—
„ „ Foundry	3 3 6	—
(3) Northampton—		
Foundry No. 3	2 19 0 to 3 0 0	—
Forge	2 14 0	—
(3) Derbyshire—		
No. 3 Foundry	3 4 0 to 3 4 6	—
Forge	2 19 0	—
(3) Lincolnshire—		
No. 3 Foundry	3 4 0	—
No. 4 Forge	3 2 6	—
Basic	3 2 6	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 2 0 (a) / 4 5 0 (b) / 4 8 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. Coast—		
Iron Rivets	11 5 0	—
Common Bars	10 5 0	—
Best Bars	10 15 0	—
Lancs.—		
Crown Bars	10 0 0	—
Second Quality Bars	9 10 0	—
Hoops	13 0 0	—
S. Yorks.—		
Crown Bars	10 10 0	—
Best Bars	11 0 0	—
Hoops	12 0 0	—
Midlands—		
Crown Bars	9 5 0 to 10 5 0	—
Marked Bars (Staffs.)	12 10 0	—
Nut and Bolt Bars	8 17 6 to 9 0 0	—
Gas Tube Strip	11 10 0	—

STEEL. (d)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	10 10 0	10 10 0
Ship Plates, ½in. and up	8 7 6	7 12 6
Sections	7 17 6	7 2 6
Steel Sheets, ¼in.	8 12 6	8 10 0
Sheets (Gal. Cor. 24 B.G.)	13 7 6	13 5 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 15 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	7 12 6	—
Soft Billets	6 15 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 5 0	—
Light Rails	8 10 0 to 8 15 0	—
Billets	7 10 0 to 10 0 0	—
Manchester—		
Bars (Round)	8 17 6	—
„ (Small Round)	7 12 6	—
Hoops (Baling)	10 5 0	10 0 0
„ (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6	—
„ (Lancs. Boiler)	10 0 0	—
Sheffield—		
Siemens Acid Billets	10 0 0	—
Hard Basic	7 2 6 to 7 12 6	—
Intermediate Basic	7 0 0	—
Soft Basic	6 5 0	—
Hoops	9 10 0 to 10 10 0	—
Soft Wire Rods	7 10 0	—
Midlands—		
Small Rolled Bars	7 5 0 to 8 0 0	—
Billets and Sheet Bars	5 15 0 to 6 0 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	—
Galv. Sheets, f.o.b. L'pool	13 2 6 to 13 5 0	—
Angles	7 17 6	—
Joists	7 17 6	—
Tees	8 17 6	—
Bridge and Tank Plates	8 12 6	—
Boiler Plates	11 0 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	18/- to 18/3
Block Tin (cash)	235 7 6
„ (three months)	235 15 0
Copper (cash)	61 17 6
„ (three months)	61 17 6
Spanish Lead (cash)	20 5 0
„ (three months)	20 12 6
Spelter (cash)	24 18 9
„ (three months)	24 18 9
Manchester—	
Copper, Best Selected Ingots	66 0 0
„ Electrolytic	67 5 0
„ Strong Sheets	92 0 0
„ Tubes (Basis Price), lb.	0 1 1
Brass Tubes (Basis Price), lb.	0 1 0
„ Condenser, lb.	0 1 2
Lead, English	21 12 6
„ Foreign	20 10 0
Spelter	24 17 6
Aluminium (per ton)	£107

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/7½ per lb.	
Ferro Tungsten	1/3 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22 15 0	7/6
„ „ 6 p.c. to 8 p.c. „	£22 7 6	7/-
„ „ 8 p.c. to 10 p.c. „	£22 5 0	6/-
„ „ Specially refined		
„ „ Max. 2 p.c. carbon	£35 0 0	12/-
„ „ „ 1 p.c. carbon	£40 10 0	15/-
„ „ „ 0·70 p.c. carbon	£50 0 0	17/-
„ „ „ carbon free	1/2 per lb.	
Metallic Chromium	2/11 per lb.	
Ferro Manganese (per ton)	£13 10 0 for home; £13 10 0 for export	
„ Silicon, 45 p.c. to 50 p.c.	£12 17 6 scale 5/- per unit	
„ „ 75 p.c.	£20 10 0 scale 6/- per unit	
„ Vanadium	14/3 per lb.	
„ Molybdenum	4/11 per lb.	
„ Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£170 to £175	
Ferro-Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.
(*Prices not stable.*)

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	13/9
„ „ Ell	14/6
„ „ Splint	16/9 to 17/-
„ „ Trebles	13/3
„ „ Doubles	12/3
„ „ Singles	11/3
Ayrshire—	
(f.o.b. Ports)—Steam	13/-
„ „ Jewel	15/6
„ „ Trebles	12/6 to 13/-
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	10/6 to 12/6
Screened Navigation	18/-
Trebles	13/-
Doubles	12/6 to 13/-
Singles	11/6 to 11/9
Lothians—	
(f.o.b. Leith)—Best Steam	11/6
Secondary Steam	11/6
Trebles	12/9 to 13/-
Doubles	12/6
Singles	11/3

ENGLAND.

(8) N.W. Coast—	
Steams	24/- to 25/-
Household	37/6 to 50/-
Coke	22/6 to 23/6
Northumberland—	
Best Steams	13/6 to 14/-
Second Steams	11/9 to 12/-
Steam Smalls	9/- to 9/6
Unscreened	11/9 to 12/-
Household	21/- to 27/-
Durham—	
Best Gas	15/- to 15/3
Second	13/3 to 13/9
Household	21/- to 27/-
Foundry Coke	17/6 to 18/-

Sheffield—	Inland.	Export.
Best Hand-picked Branch	27/6 to 29/6	—
Derbyshire Best Bright House	20/- to 21/6	—
Best House Coal	19/6 to 20/6	—
Screened House Coal	16/- to 17/6	—
„ „ Nuts	15/- to 16/-	—
Yorkshire Hards	14/6 to 15/6	—
Derbyshire Hards	14/- to 15/-	—
Rough Slacks	8/6 to 9/6	—
Nutty Slacks	5/6 to 6/-	—
Smalls	2/6 to 4/6	—
Blast-furnace Coke (Inland) 13/- at ovens		
Furnace and Foundry Coke (Export), f.o.b.		17/- to 18/-

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	19/3 to 19/6
Second Smokeless Large	18/6 to 19/-
Best Dry Large	18/- to 18/6
Ordinary Dry Large	17/6 to 18/-
Best Black Vein Large	17/- to 17/3
Western Valley Large	16/6 to 16/9
Best Eastern Valley Large	16/6 to 17/-
Ordinary Eastern Valley Large	16/- to 16/3
Best Steam Smalls	12/6 to 13/-
Ordinary Smalls	11/- to 12/6
Washed Nuts	18/- to 23/-
No. 3 Rhondda Large	19/6 to 20/-
„ „ Smalls	14/- to 14/9
No. 2 „ Large	16/- to 16/6
„ „ Through	14/6 to 15/6
„ „ Smalls	12/6 to 13/6
Foundry Coke (export)	30/- to 37/6
Furnace Coke (export)	27/6 to 30/-
Patent Fuel	21/6 to 23/-
Pitwood (ex ship)	27/6 to 28/-
Swansea—	
Anthracite Coals:	
Best Big Vein Large	30/- to 32/6
Seconds	24/6 to 27/6
Red Vein	20/6 to 25/-
Machine-made Cobbles	38/- to 41/-
Nuts	37/6 to 42/6
Beans	23/- to 27/-
Peas	17/- to 18/-
Breaker Duff	8/- to 8/6
Rubbly Culm	9/6 to 10/-
Steam Coals:	
Large	17/6 to 18/6
Seconds	16/- to 17/-
Smalls	9/9 to 11/-
Cargo Through	15/- to 16/-

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham. (d) Rebate 12/6 joists and 10/- all other materials if home consumers confine purchases solely to British products.

French Engineering Notes.

(From our Correspondent in Paris.)

The Navy.

STATEMENTS which have been made of late indicate clearly the attitude of the French Navy towards the various proposals for reducing still further naval armaments. The British idea of limiting the tonnage of battleships to 30,000 tons, of lengthening their life and lowering the maximum calibre of guns meets with French approval, but their interest in the proposal is attenuated by the fact that France is really not in a position to build battleships of that tonnage. Apart from the cost which renders the construction of battleships undesirable at a time when the whole available resources must be devoted to the reconstitution of a light and powerful mobile fleet, there are no dockyards in France where it is possible to build battleships even of 30,000 tons. It is only just possible to build the 10,000-ton cruisers. It was expected that Parliament would have voted the funds for the proposed reconstruction of the arsenal at Brest, where it is intended to provide means for building larger vessels, if necessary; but the project could not be discussed before the dissolution of Parliament, and it is therefore likely to be deferred for a considerable time. For the moment there is no question of building new battleships, and the entire resources are being concentrated upon a fleet of light vessels which it is intended to make as efficient and powerful as possible. The French programme institutes a new policy of opposing a mobile fleet of numerous small vessels to the heavily armed fleets of other Powers. It is a development of the policy formulated by Admiral Aube about thirty years ago, when the introduction of the submarine led him to believe that future naval strategy would be entirely changed by the supposed irresistible attacks of a considerable number of small and partly invisible vessels. The French do not place too much reliance upon the effective power of attack, and regard the new fleet more as an instrument of defence; but the results obtained with the new cruisers are modifying their views on this point to the extent that an extreme mobility is expected, partly, at least, to make up for an inferior armament. The new French Navy is largely in the nature of an experiment. The object is to combine speed with power. The "Tourville" has attained 36 knots on trials. The destroyers have become small cruisers, and the bigger submarines have a considerable cruising range. Any one of these vessels could be sunk by a single broadside from a modern battleship, but the mobility of the new cruisers is expected to minimise the risk of their being hit, while the main idea of attack on heavily armed vessels is a concentrated fire of torpedoes. So long as the French have faith in the efficiency of the new navy, they will not take part in any discussion that aims at a reduction or restriction of light craft or their armament. They intend to preserve absolute liberty in carrying out the naval programme.

Machine Tools.

All branches of the manufacturing industries have been lying under a cloud ever since a beginning was made to stabilise the national currency, and the situation is probably worse now that the general elections appear to have brought the country to a turning point when it has to be decided whether the work of stabilisation will continue or whether a new policy will be entered upon. Despite the uncertainty it cannot be said that work is lacking, for many of the big firms are fairly well employed, notably some of the motor car builders, and it is observable that efforts are being made everywhere to modernise plants and cheapen production. That is benefiting machine tool makers, who find their position improved by the higher import duties, but it cannot be said that the duties have benefited buyers to the same extent. In a general way French machine tool design is a long way behind that of some other countries, and there are many types of foreign machine tools that must be purchased, although the prices are now so high that the demand is largely for second-hand machines. Engine lathes, milling and boring machines, shapers and drilling machines and small automatic lathes are supplied by French makers, but high-duty turret lathes, gear-cutting machines, grinding and other big machine tools have, for the most part, to be imported, and although on account of the prices business is not large, competition is nevertheless very keen, mainly from Germany and Switzerland, for certain classes of machines, but there is no reason why British machine tools should not meet with a bigger demand when the franc is stabilised and values approximate more closely to those in countries with normal currencies.

Electrical Propaganda.

The consumption of electricity is generally keeping pace with the supply, which is growing so rapidly with the carrying out of hydro-electric schemes that it is feared it will largely exceed requirements unless something is done to stimulate consumption. In industrial centres electricity is superseding all other forms of motive power, largely on account of its convenience; but it is not usually economical unless the user can increase his consumption sufficiently to secure the full rebate, and even then the cost is appreciably above that of energy supplied by a suction gas or oil engine plant. The cost of electricity is, in fact, higher than had been promised when the electrification scheme was started with the idea that in time the whole country would be supplied with a cheap as well as a convenient form of energy. Too little account had been taken of the cost of distribution and maintenance, which far exceeds the original estimates, and the companies are therefore hoping to bring down the price to consumers by opening up new sources of consumption. The greatest scope lies in encouraging the use of commercial vehicles with secondary batteries which could be recharged at night at low cost, and trials have been organised from time to time to demonstrate the economy of that form of motive power, especially in view of the new fiscal legislation which tends to increase the price of imported liquid fuels. The plan of the electricity companies is to popularise the electric commercial vehicle, so as to provide a continuous full load on the power stations and also eventually to install automatic re-charging stations along the roads to permit of electric vehicles running all over the country.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

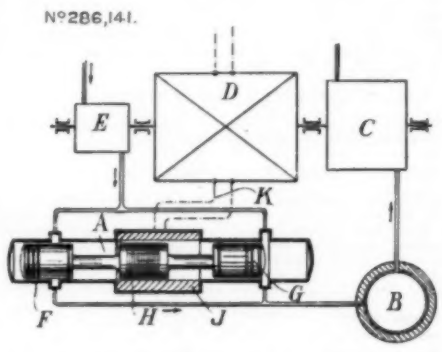
Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

286,141. June 27th, 1927.—INTERNAL COMBUSTION TURBINES, W. G. Noack, Rütistrasse 12, Baden, Switzerland.

This invention relates to an internal combustion power plant in which the working substance, consisting of very hot gas under high pressure, is produced in a reciprocating engine and expanded to do useful work in a gas turbine, the reciprocating engine being of the free piston type and coupled to a reciprocating electrical generator for the purpose of securing uniform running. The current obtained from this generator may be used to drive a motor for operating other auxiliary machines, or the two generators, *i.e.*, the reciprocating generator and the rotary generator driven by the gas turbine, may be operated in parallel. In either case the primary object of electrically connecting the two machines is to ensure the uniform working of the free piston engine. Should the free piston engine fall out of step or be in danger of stalling, for example, owing to ignition trouble or other reasons, then either the motor driving the auxiliaries—which would then work as a generator—or the main generator would act as a fly-wheel until proper working conditions had been restored. In order to secure the necessary reliability for the gas turbine with the materials at present available it is essential that the working fluid should not exceed a certain maximum temperature. The less the expansion in the first row of nozzles the lower will be this maximum temperature. In order that the allowable temperature for the blades shall not be exceeded it is necessary either to avoid using rich mixtures or to cool the exhaust gases as they leave the internal combustion engine by the addition of cold air. This may be performed in a mixing chamber immediately before the gas turbine. The same result is obtainable by

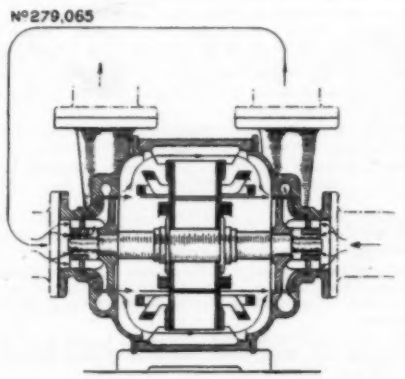


an abundant use of scavenging air, particularly with the free piston engine working as a two-stroke engine. The high-pressure air necessary for this purpose may be conveniently obtained from a piston type compressor driven, together with the reciprocating generator, from the free piston engine. To keep the stroke volumes of the free piston engine and compressor as small as possible the air should be pre-compressed. For this purpose a so-called supercharging blower is employed which may be either driven by a motor which draws its current from the reciprocating generator or coupled to the main generator or gas turbine. The simplest arrangement of plant is obtained when no attempt is made to use the reciprocating generator for power supply purposes, its function being confined to that of a stabiliser for the free piston engine. In this case the whole of the power developed by the free piston engine is applied to the compression of air in the piston compressor, and the reciprocating generator, although electrically coupled either to the main electrical machine or to a special fly-wheel generator, runs practically unloaded. In the figure the reference character A denotes the free piston engine, B an equalising chamber for the exhaust gases, C the gas turbine, D the main generator, and E a blower for supplying scavenging air or air for combustion, which latter may be more or less pre-compressed. The pistons F and G are attached to the field magnet H of the reciprocating generator by means of piston-rods. The reciprocating motion of the field generates an alternating current in the windings—not shown in the drawing—of the stator J, and this current is led through the conductors K to the main electrical machine D and relieves the turbine C from the load due to the blower E.—*March 1st*, 1928.

DYNAMOS AND MOTORS.

279,065. October 4th, 1927.—COOLING ARRANGEMENT FOR ELECTRIC MOTORS DRIVING MULTI-STAGE FORCE PUMPS, Maschinenfabrik Oerlikon, of Oerlikon, near Zürich.

The circulating of cooling medium in the interior of the motor

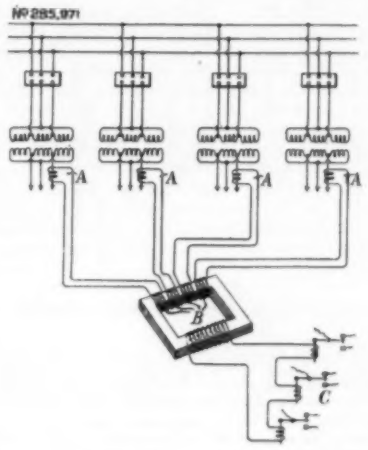


is produced by placing the motor between two pressure stages of the pump, so that a portion of the medium flows from the high-pressure stage through the motor to the low-pressure stage. The cooling medium may be paraffin oil or other liquid that is not liable to damage the windings of the motor.—*March 1st*, 1928.

SWITCHGEAR.

285,971. November 23rd, 1926.—IMPROVEMENTS IN AND RELATING TO AUTOMATIC CONTROL SYSTEMS FOR DYNAMO-ELECTRIC MACHINES, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, W.C. 2, and Cyril John Sarjeant, of "Mark Ash," 4, Dunsmore-avenue, Hillmorton Paddox, Rugby.

This invention relates particularly to the control of automatic sub-stations, and the object is to provide an improved method

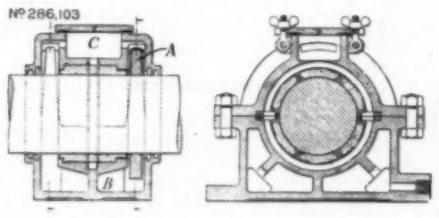


of starting and stopping the machines as required. Current transformers A are provided in the low-tension side of each power transformer connected to the respective machines. The secondary winding of each current transformer is then connected to separate primary windings B on a summation transformer, and the secondary winding of this transformer is connected to relays C set to operate at different current values, so that the various machines are started and stopped according to the load.—*February 23rd*, 1928.

TRANSMISSION OF POWER.

286,103. March 24th, 1927.—SUPPLYING OIL TO BEARINGS, Michell Bearings, Ltd., South Benwell, Newcastle-on-Tyne; and H. B. Scott, 48, Harley-terrace, Gosforth, Northumberland.

In the specification it is pointed out that where a bearing is made of a series of pads, whether they be pivoted or fixed, there

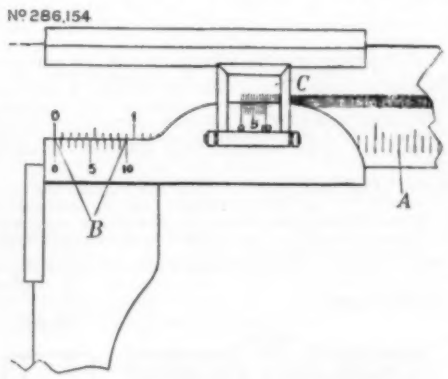


is a liability for some of the pads to be starved of lubricating oil if the oil is supplied only at one point. The inventors consequently use "pumps," in the form of collars, such as that at A, on the shaft, to raise the oil from the reservoir B to the distributing chamber C. Thence the oil goes by passages of diminishing cross section to the leading edges of the pads, so that each pad secures its proper share of lubricant.—*March 1st*, 1928.

MEASURING AND TESTING INSTRUMENTS.

286,154. July 27th, 1927.—VERNIER MEASURING INSTRUMENTS, M. R. Borel, 14, Faubourg St. Etienne, Pontarlier, France.

The essence of this invention is the provision of two separate verniers on a measuring instrument, such as a set of sliding callipers. As shown in the illustration, the rough dimension is



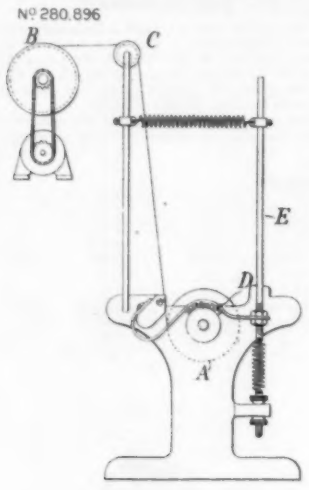
indicated by the divisions A; these may be subdivided by the vernier B and a final refinement is provided by the vernier C. The last vernier is viewed through a magnifying glass. In this way, it is claimed, one-hundredths of a millimetre may be observed.—*March 1st*, 1928.

MACHINE TOOLS AND SHOP APPLIANCES.

280,896. November 4th, 1927.—TENSIONING DEVICES FOR WIRE COILING MACHINES, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C. 2.

This device is intended to provide the tension necessary in winding tight coils of fine wire and is claimed to be more smooth

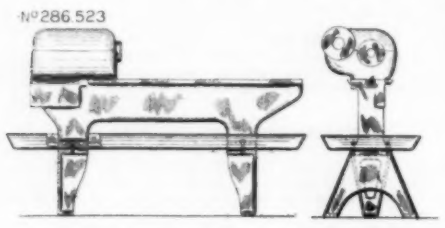
in its action than the usual arrangements. The wire is wound from the supply spool A to the coiler B over the guide pulley C. The spool A is checked by the brake D, which is mounted on a springy arm. If the tension in the wire increases the guide pulley



moves to the left and pulls the rod E with it. This tends to lift the brake block and, at the same time, open out its curvature. The latter action, especially, tends to produce the gentle gradation of the braking effect desired.—*March 8th*, 1928.

286,523. June 7th, 1927.—Turning Lathes, Sir A. Herbert, Dunley Manor, near Whitchurch, Hants, and P. V. Vernon, Keresley Manor, Keresley, near Coventry.

This specification hardly requires illustration. It aims at the prevention of the distortion of a lathe bed through resting on an

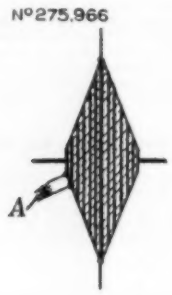


uneven floor. The claim is for the use of three legs, instead of the usual four, and it is advised that the bottom of the legs should be rounded. It is agreed that three-point support is not novel, but that its application to such machine tools is claimed to be new.—*March 8th*, 1928.

MISCELLANEOUS.

275,966. July 29th, 1927.—Improvements in or relating to Lead-in Insulators, particularly for Electric Apparatus, *Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.*

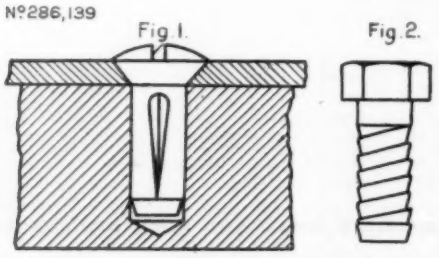
This invention consists of an arrangement in connection with lead-in insulators of electrical apparatus, and the object is to avoid or damp local oscillations. In the illustration, a resist-



ance A is shown connected between some of the outermost plates of the condenser bushing. If, the specification states, resistances of suitable ohmic value are arranged at numerous places on the insulation, the waves occurring in the insulation will be damped at all these places and their action will be weakened. Moreover, the appearance of local oscillations with their injurious excess tensions will be restricted.—*March 1st*, 1928.

286,139. June 22nd, 1927.—A Nail for Nailing Metal, G. Schäfer, 50, Königsbrückstrasse; and P. Reichardt, 5, Melonchthonstrasse, Klotzsche, Germany; and Kerb-Konus G.m.b.H., 15, Industie-gelande, Planitzstrasse Dresden N., Germany.

This invention is virtually concerned with the nailing of metal



to metal by means of blunt-ended nails driven into bored holes. The nails are provided with projections, which may be axial, as shown in Fig. 1, or transverse, as indicated in Fig. 2. It is claimed that the deformation of these projections in the process of driving will provide the necessary holding force, but no mention is made of the elasticity of the material which is suitable for rivets made for this purpose. It is said that the hole is not damaged by the driving of the nail.—*March 1st*, 1928.

274,079. July 4th, 1927.—Improvements in or relating to Enamelled Wires, N. V. Philips' Gloeilampenfabrieken, of 6, Eindhoven, Holland.

The invention relates to very thin enamelled wires. The metal core of enamelled wire described in this specification consists of a highly refractory metal that is only oxidisable with difficulty, or of an alloy of such metals. The core may have a diameter of only 10 microns. The wire may be used for winding electric coils of limited dimensions, with which very high self-inductances must be obtained. Such coils constitute, for example, the windings of wireless transformers. All metals having a melting point of the order of 2000 deg. Cent. or higher may be used. Molybdenum is preferable for the core of the enamelled wire. Compared with an enamelled copper wire, an enamelled molybdenum wire has the advantage that it does not possess the harmful property of quickly becoming oxidised. There is not, in fact, any risk of oxidation occurring even when it has a diameter of 10 microns.—*March 1st*, 1928.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

TO-DAY.

Institution of Municipal and County Engineers.—Visit of the West Midland District to the bridge over the Severn, Holt Fleet, near Droitwich. 3 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. "Calculating Apparatus and Diagrams for Engineers," by Mr. A. P. Morris. 7.30 p.m.

The Institution of Engineering Inspection.—At the Rooms of the Royal Society of Arts, John-street, Adelphi, London, W.C. 2. "Low-temperature Carbonisation," illustrated by lantern slides, by Mr. R. P. Wilson, in collaboration with Mr. C. H. Parker. 7.30 p.m.

FRIDAY AND SATURDAY, APRIL 13th and 14th.

The Institution of Municipal and County Engineers.—East Midland District Meeting at Skegness.

SATURDAY, APRIL 14th.

Institute of British Foundrymen: Lancashire Branch.—At the College of Technology, Sackville-street, Manchester. Mr. Jos. Hogg, of Burnley, will open a discussion on "A Foundry Problem," whilst Mr. Holland, of Manchester, will read a short paper on "Refractories." 4 p.m.

MONDAY, APRIL 16th.

Railway Club.—25, Tothill-street, London, S.W. 1. "South American Railways," by Mr. B. M. Bazley. 7.30 p.m.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. Dr. Mann Lecture, "Applied Architectural Acoustics," Lecture 1, by Mr. A. G. Huntley. 8 p.m.

TUESDAY, APRIL 17th.

Crystal Palace School of Practical Engineering.—166th Award of Certificates. 3 p.m.

Institution of Civil Engineers.—Great George-street, Westminster, London, S.W. 1. Paper to be submitted for discussion, "Deep-water Jetty at Bevan's Cement Works, Northfleet," by Messrs. Charles Percy Taylor and Oscar Faber. 6 p.m.

Institution of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow. "The Balancing of Internal Combustion Engines," by Professor William Kerr. 7.30 p.m.

Institution of Petroleum Technologists.—At the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. "Tube Still Distillation," by Mr. C. H. S. Edmonds. 8.30 p.m.

Manchester Geological and Mining Society.—Queen's Chambers, 5, John Dalton-street, Manchester. "High and Low-pressure Centrifugal Pumps for All Purposes," by Mr. A. W. Taylor. 4 p.m.

Society of Glass Technology.—General Lecture Theatre, the University, Western Bank, Sheffield. "Stained Glass of the Renaissance Period," by Mr. Walter Butterworth, sen. 7.30 p.m.

WEDNESDAY, APRIL 18th.

Institute of Fuel.—Chemical Society's Rooms, Burlington House, Piccadilly, W. 1. "The History and Development of Anti-detonating Agents for Motor Fuel," by Mr. H. S. Tegner. 6 p.m.

Overhead Lines Association.—At the Institution of Electrical Engineers, Savoy-place, London, W.C. 2. Discussion on "How Far Wayleave Notice and/or Agreement Form can be Standardised for Great Britain, with Advantage to All Parties Concerned," opened by Mr. W. C. Bexon, Engineer and General Manager, Ayrshire Electricity Board. 5.30 p.m.

Royal Meteorological Society.—49, Cromwell-road, South Kensington. The following papers will be read: "Some Alpine Cloud Forms," by Mr. C. K. M. Douglas; "A Strong Wind of Small Gustiness," by Mr. N. K. Johnson; "A Statistical Analysis of the Daily Observations of the Maximum and Minimum Thermometers at Rothamsted," by Mr. T. N. Hoblyn. 5 p.m.

Royal Microscopical Society.—20, Hanover-square, London, W. 1. A meeting of the Society will be held at 7.30 p.m.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. "American Architecture," by Mr. A. C. Bossom. 8 p.m.

Society of Glass Technology.—Applied Science Department, St. George's-square, Sheffield. Eleventh annual general meeting and ordinary general meeting. 2.30 p.m.

Society of Technical Engineers: London Branch.—Engineers' Club, London. "The Application of Aerial Ropeways in Industry," illustrated by lantern slides, by Mr. H. F. Shields. 7.30 p.m.

The Institute of Metals: Swansea Local Section.—In the Thomas Café, High-street, Swansea. Annual general meeting. 7 p.m.

WEDNESDAY TO SATURDAY, APRIL 18th to 21st.

Model Railway Club.—Kingsway Hall, London, W.C. 2. Sixth annual exhibition. 11 a.m. to 10 p.m. daily.

THURSDAY, APRIL 19th.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, London, W.C. 2. The Nineteenth Kelvin Lecture, "The Revolution in Physics," by Sir Oliver Lodge. 6 p.m.

The Institution of Civil Engineers: Birmingham and District Association.—Prince's Chambers, 6, Corporation-street, Birmingham. Annual general meeting. "The Sandfields Filters of the South Staffordshire Waterworks Company," by Mr. R. A. Robertson.

The Institution of Electrical Engineers.—Presentation of Faraday Medal. The Faraday Medal (seventh award) will be presented to Professor J. A. Fleming, at the ordinary meeting of the Institution, at 6 p.m.

The Institution of Mechanical Engineers: The Yorkshire Branch.—Visit to the works of J. Parkinson and Son, Shipley. 2.30 p.m., reception by the Lord Mayor and meeting in Bradford. Paper, "Toothed Gearing," by Professor G. F. Charnock. 6.45 p.m.

FRIDAY, APRIL 20th.

Chemical Engineering Group.—Visit and joint meeting with the Birmingham Section, Engineers' Club, Waterloo-street, Birmingham. "The Heat Treatment of Ferrous Metals," by Dr. C. M. Walter. 7.30 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. "An Outline of the Distribution of Petroleum," by Mr. W. M. Hurrell. Discussion and re-exhibition of slides. 7.30 p.m.

The Institution of Mechanical Engineers.—Storey's-gate, St. James's Park, London. General meeting. "The Causes of Failure of Wrought Iron Chain and Cable," by Messrs. H. J. Gough and A. J. Murphy, and "The Third Report of the Wire Ropes Research Committee." 6 p.m.

North-East Coast Institution of Engineers and Shipbuilders.—Bolbec Hall, Newcastle-upon-Tyne. "W/T Direction Finding for Marine Purposes," by Dr. S. H. Long. 6 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "Heirlooms of Industry in the Science Museum," by Colonel Sir Henry G. Lyons. 9 p.m.

MONDAY, APRIL 23rd.

The Institution of Mechanical Engineers.—Storey's-gate, Westminster, S.W. 1. Graduates' Section, London. "Pulverised Coal Systems," by Mr. H. Heywood. 6.30 p.m.

WEDNESDAY, APRIL 25th.

Newcomen Society.—Prince Henry's Room, 17, Fleet-street, E.C. 4. "Steamers of Lake Champlain, 1809 to Present Day," by Mr. L. F. Loree. 5.30 p.m.

The Institution of Civil Engineers.—Great George-street, Westminster, S.W. 1. Students' meeting. Annual general meeting of the Association of London Students. 6.30 p.m.

THURSDAY, APRIL 26th.

Junior Institution of Engineers.—Monico Restaurant, Piccadilly-circus, W. 1. Annual dinner. 6.30 p.m.

Royal Aeronautical Society.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. "Flying Boats," by Herr C. Dornier. 6.30 p.m.

The Institution of Civil Engineers: Yorkshire Association.—In the Hotel Metropole, Leeds. "Railway Construction in the Pyrenees," by Mr. C. J. Chaplin.

FRIDAY, APRIL 27th.

Institution of Engineers-in-Charge.—Venetian Chamber, Holborn Restaurant, London. Annual dinner. 6 p.m. for 6.30 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "Carriers of Electricity in the Atmosphere," by Dr. Arthur M. Tyndall. 9 p.m.

The Institution of Mechanical Engineers.—Storey's-gate, Westminster, S.W. 1. Informal meeting. "Pulverised Fuel in Locomotive Furnaces," introduced by Mr. J. Clubley Armstrong. 7 p.m.

THURSDAY, MAY 3rd.

Iron and Steel Institute.—Connaught Rooms, Great Queen-street, London, W.C. 2. Annual dinner. 7 for 7.30 p.m.

THURSDAY AND FRIDAY, MAY 3rd and 4th.

Iron and Steel Institute.—At the house of the Institution of Civil Engineers, Great George-street, London, S.W. 1. Annual meeting. For Programme see page 375.

FRIDAY, MAY 4th.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "Credit and Currency," by the Right Hon. Reginald McKenna. 9 p.m.

TUESDAY, MAY 8th.

The Institute of Metals.—The Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. Eighteenth annual May lecture, "The Chemical Properties of Crystals," by Professor Cecil H. Desch. 8 p.m.

THURSDAY, MAY 10th.

Royal Aeronautical Society.—At the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. "Design and Construction of Modern Rigid Airships," by Mr. B. N. Wallis. 6.30 p.m.

WEDNESDAY, MAY 16th.

Overhead Lines Association.—At Institution of Electrical Engineers. Mr. D. C. Redfern, Engineer, Lothians Electric Power Company, will open a discussion on "Standard Overhead Lines: Their Advantages and Number of Different Standards Required." 5.30 p.m.

Royal Metal Trades Pension and Benevolent Society.—Second annual golf competition at Sundridge Park Golf Club, Bromley, Kent.

The Institution of Electrical Engineers: Inspection of the Singapore Floating Dock.—By the courtesy of Swan, Hunter and Wigham Richardson, Ltd., and with the permission of the Admiralty, arrangements have been made for a party of members of the Institution of Electrical Engineers to inspect the Singapore Floating Dock at Newcastle-on-Tyne, on Friday, April 27th, 1928. An invitation to take part is extended to all members of the Institution, and those wishing to join the party should communicate without delay with Mr. H. B. Poynder, hon. secretary of the North-Eastern Centre, Carliol House, Newcastle-on-Tyne. After the inspection Mr. E. T. Williams, Assistant Director of Electrical Engineering at the Admiralty, will deliver a lecture on "The Electrical Equipment of the Singapore Floating Dock." The lecture will be followed by a discussion.

A Seven-Day Journal

The World's Fastest Cruiser.

JUDGING from the reports of their trials, the new French cruisers "Duquesne" and "Tourville" would appear to be the fastest warships of that type in existence. Each nominally displaces 10,000 tons, and is engined with Rateau geared turbines of 130,000 S.H.P. On her initial full-power run the "Duquesne" registered 135,000 S.H.P., with a resulting speed of 35·3 knots, a performance the more remarkable because the run was made in comparatively shallow water. At this time the ship displaced rather more than 10,000 tons. On an earlier endurance trial, at a displacement of 11,700 tons, she averaged 33·6 knots for eight hours. Admirable as these results are, they have, according to semi-official reports, since been eclipsed by the sister ship "Tourville." During her preliminary trials in March, when not under a full head of steam, that vessel developed 105,000 S.H.P. and reached 34·3 knots. This performance was greatly improved upon at the full-power trial early in April, when a maximum speed of 36·15 knots was recorded. Assuming the trial figures to be reliable, the "Tourville" is easily the fastest cruiser in the world, with the "Duquesne" a close second. This distinction had hitherto been claimed for the American cruiser "Omaha," which is said to have reached 34·87 knots on her trials. As the trial results of British warships are not published, it is impossible to say how they compare with the foregoing figures, but our fastest cruisers appear to be the "Emerald" and "Enterprise," with a designed speed of 33 knots. Even the "Tourville" may be outclassed by the 5000-ton cruisers now being built in Italy, which have a contract speed of 37 knots with 95,000 S.H.P.

Wireless Direction Finding.

A SUMMARY of the work carried out by the Radio Research Board, established under the Department of Scientific and Industrial Research, is contained in a report on Radio Direction Finding by Dr. R. L. Smith Rose. Many of the results obtained during the progress of the investigations have been previously published in the form of official reports, and these constitute a record suitable for those interested in exact details of the measurements obtained. The object of the present report is rather to give a comprehensive survey of the subject, as a result of the investigations, and to supplement the previous records with further results obtained during the past two years. A summary is given, in the first section of the report, of the early development of wireless direction finding up to the year 1921, when the investigations of the Radio Research Board were begun. For the purpose of making systematic observations on the transmissions from various European stations, ten identical direction-finding stations were erected in 1921 in the British Isles and operated under the control of the National Physical Laboratory at Teddington. At a later date two other stations were put into operation, thus completing a network from Oxford on the East Coast to Bristol and Belfast in the West and to Aberdeen and Lerwick in the Shetland Islands in the extreme North. These stations were employed for taking regular daily observations over a period of from two to five years, and the results obtained have been analysed in detail, and are discussed in this and the preceding reports. The co-ordination of the large quantity of data obtained during the course of the investigation has furnished very exact information as to the actual nature and magnitude of the various effects observed, and the results are found to be in good agreement with the observations made in other countries, as widely scattered as France, Germany, America and China. As a result of the investigation, a system of direction-finding has been developed which is said to be free from erratic night errors. The report is published by H.M. Stationery Office.

The Late Mr. Harry J. Cornish.

THE death of Mr. Harry John Cornish, which took place at his home in Hampstead on Sunday last, April 15th, will be the cause of wide regret in shipping and shipbuilding circles. Mr. Cornish, who was eighty-eight years of age at the time of his decease, was Chief Ship Surveyor to Lloyd's Register of Shipping, and he retired from that position in 1909, after serving the society for forty-six years. He was born at Devonport in 1839, and came of a seagoing family. After a private education, Mr. Cornish began his career in naval architecture at Deptford Green Dockyard, and in 1858 he gained experience on the completion and preparation for sea of the steamer the "Great Eastern." In 1863 he entered the service of Lloyd's Register as a ship surveyor, and soon gained notice, not only on account of his professional abilities, but because of the excellency of his draughtsmanship and artistic work. When in 1867 the Society's rules for composite ships were formulated, Mr. Cornish's illustrations were selected from among others and were accepted by the Committee. They were afterwards exhibited and gained awards at the International Exhibitions at Paris and Moscow, and are now to be seen in the South Kensington Museum. In 1870 Mr. Cornish was appointed assistant to the Chief Ship Surveyor, the late Mr. Benjamin Martell, and he served in that capacity for thirty years. On the retirement of Mr. Martell, Mr. Cornish was made Chief Ship Surveyor, which office he held until 1909, when he retired. He was elected a member of the Institution of Naval Architects in 1876, and was made a member of Council in 1900. Four years later he was elected a Vice-president of the Institution, and he became an Honorary Vice-president in 1916. He gave one paper in 1905, which was entitled "The Classification of Merchant Ships, illustrated by a Short History of Lloyd's Register." Mr. Cornish saw a great change take place in naval architecture and marine engineering during his long career. In his earliest experiences he had to do with the steamer "Great Eastern," and in his later years he was constantly in touch with the owners and builders of the famous Atlantic liners the "Lusitania" and "Mauretania" concerning their design.

The Persian Railway Contract.

AT a meeting of Julius Berger and Co., of Berlin, held last week, it was announced that a German group of contractors, including Berger and Co., the Siemens Bau-Union and Holzmann and Co., has obtained from the Persian Government a contract for constructing a railway from the Caspian Sea to the Persian Gulf. The length of the proposed line is given as 1700 kiloms., or 1056 miles. It will be built at a cost, it is estimated, of between 20 and 25 million pounds. In order to obtain a more exact idea of the actual cost, preparatory work has been begun at both ends of the proposed line, on stretches of track 100 kiloms. southward from the Caspian Sea and from the Persian Gulf northwards. As soon as the cost of the whole line can be assessed, further negotiations are to be conducted with the Persian Government with a view to completing a final contract. Meanwhile, so it is stated, an agreement has been made with Messrs. Ulen and Co., a firm of American contractors, whereby the southern section of the line from Hamadan to the Persian Gulf, when sanctioned by the Persian Government, will be built by a group of American, English and French contractors, leaving the northern section from the Caspian Sea to Hamadan to be constructed by the German group. It is thus possible that some of the sub-contracts may be gained by British interests, but they seem likely to be but small portions of the whole contract.

Transmission Line Towers.

TESTS are shortly to be made on one of the steel transmission towers to be used in connection with the Central Scotland Electricity Scheme. The structure will be assembled in sections in Glasgow, and at the testing station at Erith it will be subjected to stresses very much in excess of anything the towers will have to stand in practice. By the adoption of "Malone anchors," the contractors expect to reduce the cost of erection to a low figure. In accordance with this method of erection, holes 5in. in diameter are bored in the earth at an angle corresponding to the four legs of the tower to a depth of about 10ft., and at the bottom of each hole a cavity of not less than 2ft. is formed by the explosion of dynamite. Into this the anchor is lowered and set, and the cavity and bore-hole are then filled in to the ground level with grout. The engineers supervising the scheme are said to have satisfied themselves that the scheme is thoroughly sound, and that it should reduce the cost of erecting the overhead lines very considerably.

The British Association.

THE King in Council has approved the grant of a Charter to the British Association for the Advancement of Science. It will be recalled that the petition for the charter was made by the President of the Association, Sir Arthur Keith, and its officers in January last. It is felt that the status of the Association as a body corporate, given by its Royal Charter, will enable it to extend its activities in the matter of grants for research. The Association benefited in this way by the liberality of the late Sir James Caird in 1912, and again more recently by the generosity of Sir Charles Parsons and Sir Alfred Yarrow. Mr. A. A. Campbell Swinton has undertaken to bear the costs of obtaining the Charter. The Association will also now be enabled, without legal difficulty, to take advantage of the recent offer of Mr. George Buckston Brown to vest in it the property of Downe House, the home of Charles Darwin, as a national memorial. This year the British Association is to meet in Glasgow in September, and next year, following its policy of meeting periodically in one of the Dominions, the meetings will be held in South Africa.

An East to West Atlantic Flight.

ON Thursday morning, April 12th, the German aviators, Captain Hermann Koehl and Baron von Hünefeld, along with Major Fitzmaurice, Chief of the Irish Free State Air Force, left Baldonnel Aerodrome, Dublin, at 5.38 a.m. for New York, on the Junkers monoplane "Bremen." Shortly after seven o'clock the aeroplane passed out to the Atlantic at Galway coast and was sighted at half-past three the same afternoon by a ship 880 miles from Ireland. No news was received throughout Friday, and fears were entertained for the safety of the airmen, but on Saturday the landing of the "Bremen" at Greenly Island, in the Belle Isle Strait, between Newfoundland and the coast of Labrador, was reported. The aviators were forced down for lack of fuel, and landed on a small ice-covered lake on Greenly Island, at 5.30 p.m. Friday afternoon, or 12.30 British time. For about thirty hours at the beginning of the flight the weather was favourable, but head winds, fog and storms were afterwards encountered, which delayed the flight, made bearings uncertain, and used up fuel. This successful crossing of the Atlantic from east to west for the first time by a heavier-than-air machine has justly been acclaimed as a feat of courage and endurance. but it records nevertheless the dependence of such a crossing on satisfactory weather conditions. In landing upon the ice some parts of the "Bremen" were damaged, and it was not found possible to repair the machine in such a way as to permit it to complete the flight.

A British-American Financial Combine.

ON Friday last, April 13th, the announcement was made that an alliance of British and American industrial and banking interests had been effected which would have a far-reaching effect in world industry. The new combine, which has been formed under the style of the Finance Company of Great Britain and America, has a nominal capital of £2,040,000. The ordinary shares will not be placed on the market, but will be held in equal proportions by the Chase Securities Corporation of New York, which is closely connected with the Chase National Bank. The British board of directors will have as its chairman Sir Alfred Mond, with Sir Harry McGowan as deputy chairman, while Mr. Clarence Graff and Mr. James Henry Gannon are to be joint managing directors. An American committee has been formed under the chairmanship of Mr. Albert Wiggin, and its membership includes prominent leaders in the banking, engineering, railway and steel industries of America. Sir Alfred Mond and Sir Harry McGowan will also be members of this committee, and will provide a liaison between it and the British board. The new company will, through its associations, it is stated, command a backing of no less than £500,000,000 in capital and credits. Its functions, Sir Alfred Mond has explained, are not to be those of the usual investment trust, but they will rather be directed towards the development of new processes and the increase of production. In this work the company will be supported by technical experts drawn from a very wide range of industries, both in Great Britain and in America.

A New Irish Cross-Channel Service.

SOME reference has already been made in these columns to the new arrangement whereby the London, Midland and Scottish Railway Company will in future concentrate its Belfast services at the Port of Heysham. Three new geared turbine steamers have been specially designed for this service by William Denny and Bros., Ltd., Dumbarton, and on Tuesday last, April 17th, the inaugural trip from Heysham to Belfast was made on the "Duke of Lancaster." The new service, which will begin at the end of this month, will enable passengers to leave Euston at 6.15 p.m. and arrive at Belfast at 6.30 a.m. the following morning, while on the return journey the boat is scheduled to leave Belfast at 9.15 p.m., the connecting train arriving at Euston at 11.10 a.m. the next day. The new boats are well appointed and excellent sleeping accommodation is provided. On Tuesday last Sir Josiah Stamp, the chairman of the London, Midland and Scottish Railway, travelled with guests of the company and welcomed them at a luncheon held in Belfast. The Prime Minister of Northern Ireland, responding to the toast of his Government, made the suggestion that Sir Josiah should ask his executive committee to consider the question of further accelerating the service, so that the ships would arrive in Belfast half an-hour earlier than at present contemplated, in order that letters from all parts of England might be delivered in Belfast by the first post. The two other steamers, the "Duke of Argyll" and the "Duke of Rothesay," will shortly be placed in commission.

A Proposed New Motor Road.

AT a meeting of representatives of industrial interests, which was held at Birmingham, on Wednesday, April 18th, a project for a new motor road between Birmingham and Birkenhead was discussed, and promise of support was obtained from business concerns in Birmingham, Wolverhampton and the Potteries towns, as well as Birkenhead and Liverpool. The proposed road, which would link up the Mersey Tunnel with the Smethwick side of Birmingham, would have a length of about 90 miles. The estimated cost of the road, including junctions with existing roads, is given as about £6,000,000.

General Development of the Locomotive.

(By a Continental Engineer).

No. II.*

The diameter of the driving wheels should, as a principle, be inversely proportional to the number of coupled axles, but this principle has led to serious mistakes, in some countries, in the design of the first 4–6–0 passenger engines built and intended for express service on easy lines. A kind of legend had spread, say, about a quarter of a century ago, that American railways ran express trains with six-coupled engines having wheels of very moderate diameter, between 5ft. 4in. and 5ft. 7in. It resulted in the building, in continental Europe more especially, of some ten-wheel engines carried on wheels of 1·75 m. to 1·78 m. (69in. to 70in.), which, though they could run fast when needed—notably those with four cylinders and well balanced—did so not without strain and sometimes hot boxes. It had simply been forgotten that the said engines in the United States were generally employed upon very heavy trains, at an average speed not exceeding 40 miles an hour. When American railways created really fast trains—N.Y., Central and Pennsylvania Railroads—they were the first to come to large wheels; to-day, the diameter of driving wheels on their standard "Pacific" engines for express trains reaches 79in., and even more. In France, the diameter of driving wheels of the last 4–6–2 engines built have the same diameter as those of four-coupled engines—77in. to 81in.—a rational thing to do, since both types of engine are designed for the same fast services. But we seldom, if ever, see six-coupled express engines having wheels of 7ft. or more. It is no longer necessary to demonstrate that engines using large wheels run more freely at high speed, but nobody would dream of coupling wheels of 7ft. 6in. or 8ft., like those used on the old single engines of British railways, as it would mean the adoption of enormous cylinders, in view of the heavy weights to be drawn. Generally speaking, locomotive engineers have adopted, for express engines, the maximum diameter of wheels they think necessary, but they have had to reduce it as the weight of trains increased. It seems probable that a diameter of 6ft. 9in. will not be exceeded in the future. But it will always be beneficial to use, for long-distance express trains, engines having the minimum number of coupled axles consistent with the weight of the trains and the necessity of quick starting.

In what concerns goods trains, it must be noted that years ago, on British railways, they were light and relatively fast. Only six-coupled engines were used, their wheels being from 5ft. to 5ft. 3in. in diameter. At the same period French railways used eight-coupled goods engines with wheels only 4ft. 2in. to 4ft. 3in. diameter. Now, the practice is partly reversed. British goods, and especially mineral trains, have become heavier and the eight-coupled engines, which pull them are carried on wheels not exceeding 4ft. 6in. in diameter on many sections. On the other hand, on certain main lines in France having only two tracks, the goods traffic has become difficult to handle, and it is necessary, in order to cope with it, to increase the speed, inasmuch as the brake power is generally greater than in England. The result is that now the most powerful modern eight-coupled engines and even "Decapods," have wheels of 4ft. 9in. to 4ft. 11in. —British eight-coupled, 4ft. 7½in.—diameter. The P.L.M. Company was amongst the first to follow this practice, as early as 1890—wheels of 4ft. 11½in.—but at a later date these engines were constructed with a leading Bissel truck, and, later yet, a 4–8–0 with a bogie. Their weight in working order was 75 tons. But the same company owned also a number of 0–8–0 engines having 4ft. 3½in. wheels. In reality the 4–8–0 engines were mixed traffic locomotives, and hauled passenger trains on heavy gradient lines, or stopping trains. They were very quick in starting.

The same evolution has taken place in America, for eight or ten-coupled locomotives have now wheels of 4ft. 8in. to 5ft. 3in., and even exceptionally 5ft. 7in. diameter, instead of 4ft. 2in. to 4ft. 7in., as was the practice thirty or forty years ago; but many of these engines are mixed traffic locomotives, hauling passenger trains on very long inclines.

Now, between certain limits, the diameter of locomotive wheels is not solely determined by technical or, at least, theoretical considerations, but by the practical necessity of not having in stock an excessive variety of spare tires. This is the reason why wheels of the same diameter, on a given line, are to be found on engines of the same class, but different in other respect and of different periods.

However, the greatest adhesive weight possible, even for express engines, is nowadays a necessity in many countries in view of the need of handling in all circumstances, and of starting quickly, heavy trains running at average speed. On certain French lines, for example, fast trains of 500 to 600 tons behind the tender are no longer exceptional. Everywhere, the public has profited by the great increase of power of the engine, which permits the use of much more comfortable coaches, corridor cars, and vestibuled trains, and, on the Continent, the introduction of third-class carriages in express trains.

* No. I. appeared April 13th.

Among the noteworthy steps that took place in the last period of evolution of the locomotive, we must note the giving up of total adhesion and the adoption of an increasing number of uncoupled axles. This is particularly true of American engines, as seen in 4–8–2, 2–10–2 and even 4–12–2 locomotives. In other words, the four-coupled engine, the classic locomotives of twenty-five years ago, has given birth to the "Atlantic" type; the six-coupled to the "Mogul," "Prairie," and "Pacific"; and the eight-coupled to the "Consolidation" and "Mikado" types—all having leading or trailing pony trucks or bogies. Even for tank engines, the "Baltic" type, 4–6–4, has made its appearance as a result of the need of a boiler of greater power and weight, and the necessity of increasing the stability without reducing the flexibility of the engine, and of avoiding the overhang of cylinders or of the fire-box. For six or eight-coupled goods engines, these new arrangements, though they were adopted by many railways of Great Britain, were not so necessary there as elsewhere, most engines having already inside cylinders, and because the overhung fire-box had never been tolerated as it has been far too long on the Continent. In fact, and admitting exceptions, of course, the British companies were the first in Europe to adopt the bogie on the largest scale for express locomotives, even with outside cylinders. For example, the Great Northern singles, 4–2–2, and "Atlantics," the London and South-Western four-coupled (Mr. Adams), the North-Eastern "Atlantics," the Glasgow and South-Western ten-wheeled engines, and many other precursors.

On the standard gauge the bogie was not as a rule used at first on express engines in Great Britain. If I am not mistaken, the first applications were made on tank and suburban engines, such as those of the Metropolitan Railway of London, in the early 'sixties, or on mixed traffic locomotives. When Mr. J. Stirling fitted his single express engines, hauling trains that were then among the fastest in the world, with a bogie, in about 1871, it was considered by many specialists as a bold departure. But it was soon acknowledged that the leading bogie was a great factor of security and good running, adding greatly to the stability. It is possible to say that there is not to-day an express locomotive in the world, hauling really fast trains, which is not fitted with a leading bogie. Tank engines of the 4–4–4 and 4–6–2 or 4–6–4 are best suited for running in either direction.

Articulated engines seem to diminish in favour, especially in the United States, where they have experienced the greatest development. It is now recognised that, with blind tires or thin flanges on one or two of the drivers and with sufficient lateral play given to the leading and trailing coupled axles, even twelve-coupled engines can negotiate all curves that are met with on standard lines. The "Mallet" or "Fairlie" locomotives are very complicated and do not allow more than very moderate speeds. The two motor truck engines of the Belt line of Paris have never been a great success, and are no more built. We must make an exception for the "Garratt" engines in Great Britain, when employed as pushers, as they allow the use of a very large boiler despite the small structure gauge.

The large boilers now in use on the engines of most countries are designed in proportion to the adhesive weight in order that the greatest possible tractive force may be maintained at high speeds. Thus a modern "Pacific" engine, for an adhesive weight of 59 tons, presents as an average a heating surface of 2800 square feet, in round numbers, and a grate area of 43 to 45 square feet or 0·77 square foot per ton (P.) of weight on the coupled wheels. Of course, this grate area may vary in some measure with the quality of fuel used—"Wootten" engines are not considered —but for the "Pacific" with wide fire-box it may be regarded as normally included between 0·67 P. and 0·78 P. in square feet.

The new types of locomotives, such as 4–6–2, 2–8–2, &c., result from the necessity of increasing the grate area in proportion to the adhesive weight. For example, the "Mikado" type plays, in relation to the "Consolidation" engine, about the same part as did the "Atlantic" type to the four-coupled and the "Pacific" type to the six-coupled. The power of the "Consolidation" engine is limited by the necessity of using a narrow fire-box, unless the wheels are of small diameter. For this reason the "Consolidation" engine, so much in favour in Europe from about 1906 to 1919, and still used with advantage by many systems, may be considered as an intermediate type leading inevitably to the 2–8–2 locomotive when it becomes necessary to increase the power by obtaining a greater boiler capacity and a larger grate area, which can only be got with the adoption of the wide fire-box.

But the grate area in itself is not a positive term of comparison, as it is possible to burn different weights of coal per square foot of grate per hour, according to the type of fire-box. Thus the deep fire-box has a marked superiority over the shallow fire-box, the combustion being more complete, thanks to the mixing of the gases with the complement of air admitted, either through the grate or by apertures in the fire-box door, if there is a brick arch. The upper part of the fire-box thus plays the part of a combustion chamber. It is the system followed for many years on British locomotives, a country in which combustion has been for years studied methodically—the Midland Railway might be taken as a model from this point of view—which has enabled many companies to keep so long in service engines of moderate dimensions. The system of coal premiums as it is employed on the Continent has given results contrary to those expected, in that it has rendered the driver sometimes too independent and prone to adopt by himself methods of firing which are often unscientific.

With a too shallow fire-box, some of the ignited gases, not yet completely burned, are extinguished when entering the tubes, and more small unconsumed coal is drawn through them. Moreover, the tube plate is too near to the burning coal and is liable to develop leaks. It is always a good arrangement to have the tube plate as far as possible from the fire, and from that point of view the disposition adopted for the fire-box of the "Nelson" class engines of the Southern Railway seems very satisfactory. The combustion chamber of American locomotives is an excellent arrangement, but rather difficult to realise with copper fire-boxes. As long as coal was cheap, the locomotive engineers in the United States did not attach much importance to the question of fuel economy, but nowadays they have made as thorough a study of the question as anyone else, and adopted very good arrangements with a view to obtaining complete combustion even with very bituminous coal.

The really deep fire-box, wholly carried between two coupled axles, is no longer used, as it would mean, with the grate areas to-day necessary, excessively long coupling rods. This type of fire-box, with the 4–4–0 type, had the disadvantage that the trailing coupled wheels were not loaded enough and the leading axles too much, whence the necessity of adding, under the platform, a heavy cast iron counterweight, which constituted a deadweight out of place in a locomotive, though tolerable on British engines, owing to their high rating. The deep fire-box can still be found on engines of the "Atlantic" type, by reason of the small diameter of the trailing wheels. In the 4–4–0 and 4–6–0 locomotives the rear of the fire-box is situated above the trailing coupled axle, the wheels having a greater diameter, and is in consequence higher, but it can be made sufficiently deep in the front part by giving a great inclination to the foundation ring and by setting the boiler higher than in the past.

With the "Pacific" engines and the wide fire-boxes the conditions are about the same, the hindmost part of the fire-box being on top of the trailing wheels, of small diameter.

When the fire-box is deep enough and confined between the frames or the tires of coupled wheels—as in the 4–4–0, 4–6–0, or 4–8–0 engines—the inside width of the fire-box is limited to about 3ft. 3in. even if the water spaces are rather narrow. As it is impossible to fire or clean a grate exceeding about 10ft. in length, the grate area is limited to 33 or 34 square feet. With good grade fuel this is normally sufficient for powerful 4–6–0 engines having an adhesive weight of 53 to 54 tons, in Great Britain at least. But it imposes a limit and it does not allow an engine to develop power in proportion to its adhesive weight at high speed; whence the expansion of the "Pacific" type, of which the weight on the drivers is often not greater than that of the 4–6–0 engine, but which are able to haul at the same speed a heavier train or a train of the same weight at greater speed.

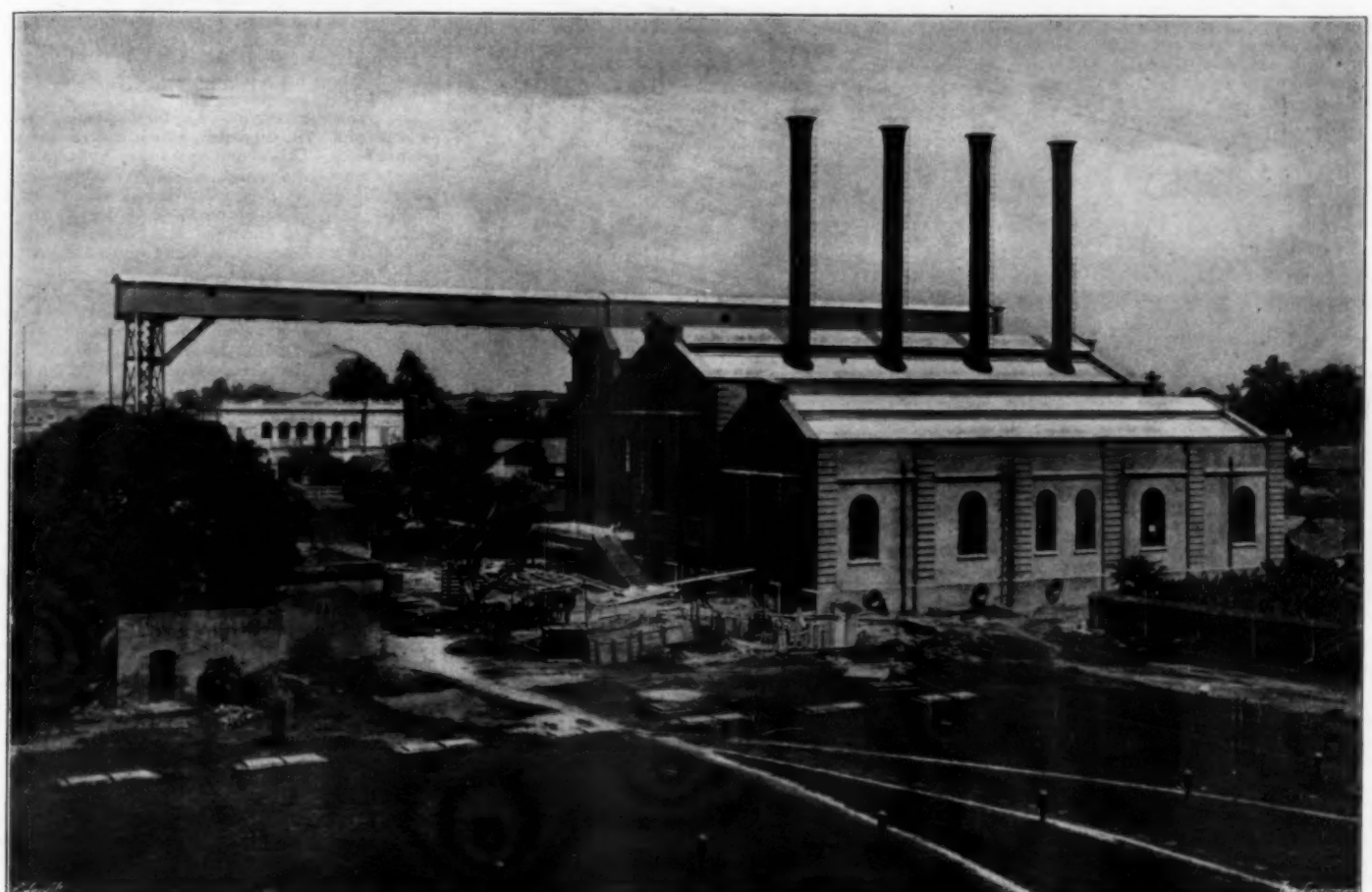
However, when coal is of very good quality with little dust, and is burnt rationally, and with an energetic draught, it may be questioned if the "Pacific" type is really a necessity, as the 4–6–0 engine may have the same adhesive weight. If its steam production is sufficient at high speeds, the ten-wheel engine will be equivalent to the "Pacific," with a greater ratio of adhesive to total weight. We have a striking example of this fact in the new engines—"Lord Nelson" class—of the Southern Railway introduced in 1926, which have a tractive effort of 15 tons, against 13·40 tons for the new "Pacific" engines of another English railway. But it must not be lost sight of that the locomotives of this type are more particularly suited for average runs, without stops, of some 85 miles It is to be feared that, for sensibly longer distances, the fires would become dirty, unless the grade of fuel were first rate, and they would lose some of their steaming capacities sooner than the "Pacific" engine having a large grate area.

In fact, to obtain a grate area exceeding 33 square feet it becomes necessary to adopt the wide fire-box spread over the trailing wheels, even though the centre of the boiler barrel be at a minimum height of 9ft. 2in. above the rail. British engineers have seldom, and quite recently only, adopted a length of grate exceeding 10ft.; indeed, they have had recourse to the wide fire-box for a grate area of 32 square feet only, as for the "Atlantic" engines of the old Great Northern. A practical advantage of this type of fire-box is the possibility of having wide lateral water spaces which permit a better circulation, are less exposed to scale and are much easier to clean. With the ordinary deep fire-box, these water spaces, often high, are generally very narrow, especially if the designer has endeavoured to obtain the maximum breadth of grate, and it is really difficult to see how good evaporation and circulation can take place.

The narrow fire-box, with a high-grade fuel, is capable of long distance runs without stops, as several English and French train services can show—London–Plymouth, &c.; Paris–Brussels, Paris–Calais, &c.

CALCUTTA WATERWORKS—PUMPING STATION AT TALLAH

MESSRS. ST. GEORGE MOORE AND LA TROBE BATEMAN, M.M. Inst. C.E., WESTMINSTER, ENGINEERS



It is impossible to pay too much attention to the design of the ashpan in order to ensure that the access of air is free and abundant. Many engines have never steamed freely for want of attention to this essential point. A good arrangement of the ashpan is more difficult to realise when the fire-box is carried over a coupled axle, as in many types of engines, or with the wide fire-box extending over a pair of trailing wheels.

(To be continued.)

Calcutta Waterworks.

No. II. *(Conclusion).**

In the first article a description was given of the intake works, purification works and pumping plant at Pulta. In what follows there is first an account of how the water is distributed throughout the city after leaving the works at Pulta. The plant for the unfiltered water supply is then dealt with.

The pumps deliver into a steel chamber 6ft. 6in. diameter, the branches connecting with the pump deliveries being 45in. diameter, set at an angle of 45 deg. to the horizontal, an extra branch being put in for future extension. One end of the chamber, from which the new main to the city commences, is tapered to 60in. diameter, and the other end to 42in. diameter, beyond which point a further reduction is made to 18in. diameter by cast iron specials, a sluice valve being fixed at the end. The existing 48in. main to the city is connected to a branch on the chamber by a length of about 1800ft. of new pipe, and a 24in. branch is also provided. The plates forming the chamber are $\frac{5}{16}$in. thick, four plates being used to the round.

From the steel chamber a 60in. steel main has been laid to a new reservoir at Tallah, a Venturi meter being inserted near the chamber. The distance to Tallah is about 13 miles and for the greater part of its length the main is laid along the Barrackpore Trunk Road, though near its northern end it passes through Barrackpore Cantonment and for a distance of about half-a-mile across Barrackpore Racecourse. The existing 48in. and 42in. mains are laid along the same line, one on each side of the road. The new main is divided into five sections by four 48in. sluice valves—see Fig. 1 *ante*. Cross connections 30in. diameter with the existing 48in. main are provided on both sides of each sluice valve, and inspection branches and air valves inserted between the valve and cross connections. No connections are made with the existing 42in. main, which will be used only as a gravitation main.

The pipes are of one plate $\frac{7}{16}$in. thick, and are made as

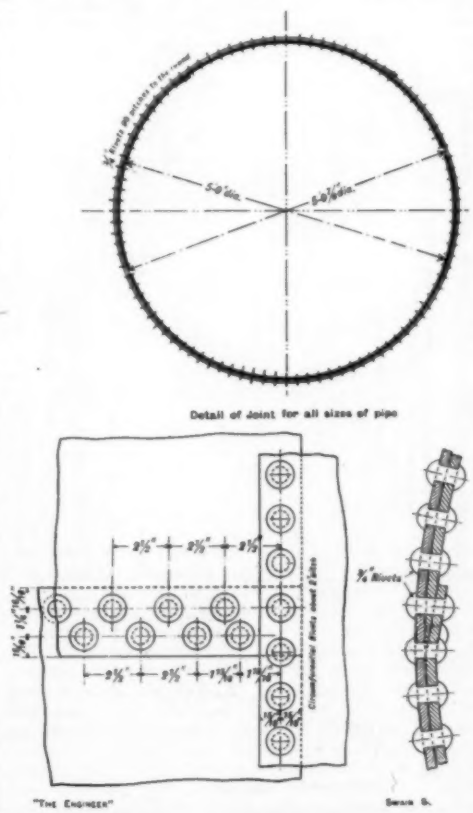


FIG. 8—60IN. STEEL PIPE

shown in Fig. 8. Bends are made to a radius of 10ft. of a length between centres of circumferential joints equal to an included angle of 1 deg., 3 deg., 5 deg., and 15 deg. as required. The edges of the plates are planed and the rivet holes drilled before shipment, the bending and riveting being done in Calcutta. The pipes are coated inside and outside with a bitumastic paint.

Fig. 9 gives a general plan of the new and pre-existing works and piping at Tallah. The total storage required for the pumps to draw upon during the period of peak consumption is 18 million gallons. The capacity of the pre-existing underground reservoir is 8 million gallons, and a new reservoir holding 10 million gallons has been constructed. This reservoir is formed of thirty-five arched bays, 15ft. wide, 300ft. long, the depth of water being 10ft. The walls, arches and piers are formed of brickwork, the foundations being of lime concrete. A division wall, provided with penstocks, divides the reservoir into two parts. The reservoir is mostly above ground, the top of the earth covering being about 13ft. above ground level and the bottom of the excavation, except where bad ground occurred, about 6ft. below. Owing to the existence of several old filled-in tanks on the site, piles were, in places, driven under the piers and walls, and the floor has been strengthened with a reinforced cement concrete mattress. In one corner, too, the bottom of the reservoir had to be lowered considerably in order to reach solid ground.

The water enters the reservoir from the 60in. main through eight lines of 24in. cast iron pipes leading to two inlet chambers, four pipes to each chamber, the ends of the pipes being provided with automatic float valves set to close at different levels. The water leaves the reservoir through six 36in. pipes, two to one outlet chamber and four to the other. In each chamber there is a 36in. overflow pipe connected to a vertical pipe on one of the 36in. outlet pipes, the overflow water passing to the existing underground reservoir. A 21in. pipe connects the deep portion at the south-east corner of the reservoir with the overflow pipe. Details of the reservoir are shown in Fig. 10, and photographs of the work under construction in Figs. 11 and 12. Fig. 11 shows in the distance the existing elevated steel reservoir. From the outlet chambers the water flows to the suction well for the new pumping station through three 54in. steel pipes, two 36in. outlets being connected to each 54in. pipe.

During peak consumption the quantity to be pumped at Tallah equals 6,902,000 gallons per hour, of which the pumping plant in existence before the commencement of the new scheme could deal with 3 million gallons per hour. The plant in the new station consists of four units each with a capacity of $1\frac{1}{2}$ million gallons per hour against a head of 130ft. Each unit comprises a 30in. Mather and Platt hydraulically-balanced split-casing centrifugal pump, coupled through double-helical, single-reduction gearing to a Parsons steam turbine, the speed of the turbine being 6000 revolutions per minute, and that of the

* No. I. appeared April 13th.

pump 650 revolutions per minute. The pumps draw from a suction culvert 8ft. high and 9ft. wide, which extends the whole length of the engine-room.

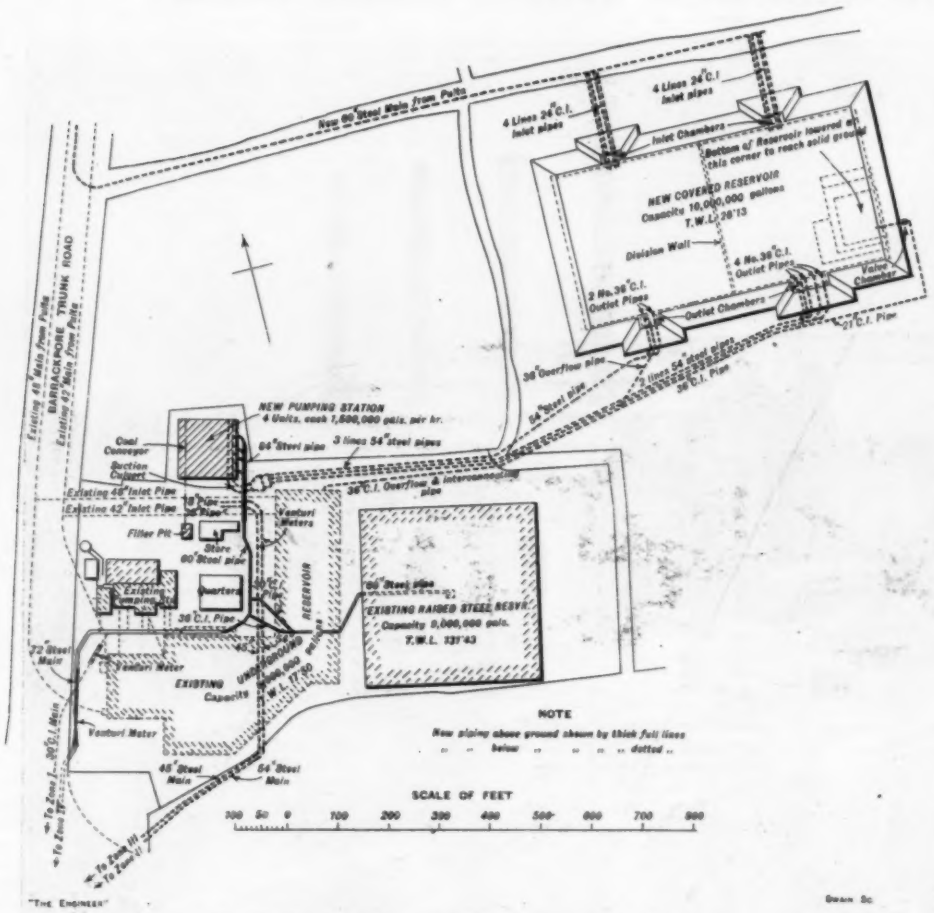


FIG. 9—GENERAL PLAN OF WATERWORKS AT TALLAH

The condensing plant for each of the sets is similar to that which is employed for the Pulta pumps. bunkers and chutes are provided, and the filler pit is situated about 100ft. from the outside of the engine-house. The steam pressure and superheat are the same as at the Pulta station.

Four 100-kW generating sets provide power for driving the auxiliary machinery and for lighting purposes. These units are exactly similar to those at Pulta and have three surface condensers, steam being supplied from the boilers for the main pumps. The pumps and generating sets are under one roof, one overhead travelling crane serving for both.

A view of the new pumping station building and coal conveyor looking in a north-westerly direction is given at the top of page 423. Fig. 15, page 434, shows the four main pumps and turbines, and Fig. 16 shows the four generating sets.

The pumps deliver into a cylindrical steel chamber or large pipe, 7ft. diameter, which is arranged above ground level. This chamber is formed of plates, $\frac{3}{16}$ in. thick, four to the round, as shown in Fig. 13. The branches for the pump deliveries, which are 42in. diameter, are set at an angle of 45 deg. to the horizontal axis of the chamber, and one extra branch is provided for future extension. One end of the chamber is tapered to 42in. diameter, and is connected to a pump delivery. The other end is tapered to 48in. diameter, and has a 48in. sluice valve attached to it. A 54in. diameter branch on the chamber connects with the main leading to Zone II.—Fig. 1, *ante*—another, 45in. diameter, with the main leading to Zone III., and a third, 36in. diameter, with the main supplying the most northerly part of the city, which is known as Cossipore-Chitpore, and which is a zone in itself. An 18in. branch is also provided.

The existing pumps deliver into a steel pipe, 72in. diameter, which is at present the main distributor to the city. Inside the compound this pipe is laid above ground and terminates in an easterly direction with a 48in. sluice valve, from which there is an extension, 60in. diameter, connecting up the pumps with the existing raised steel reservoir. A portion of this extension will be cut out, one end of the cut portion being connected by a short length of 60in. pipe to the 48in. sluice valve at the end of the steel chamber. This arrangement enables the new pumps to deliver through the steel chamber into the existing 72in. main, or the existing pumps to deliver into the steel chamber. Branches 36in. and 30in. diameter on the 60in. pipe from the steel chamber will connect with the other cut end of the pipe leading to the raised reservoir. Both these branches are provided with sluice valves and the 30in. branch is also furnished with a reflux valve, the latter being set to close against the pressure from the pumps, which enables the raised reservoir to be filled and drawn upon in the most advantageous manner.

As already mentioned, the arterial mains for Zones II., III., and for Cossipore-Chitpore commence at the 7ft. diameter steel chamber. A pre-existing

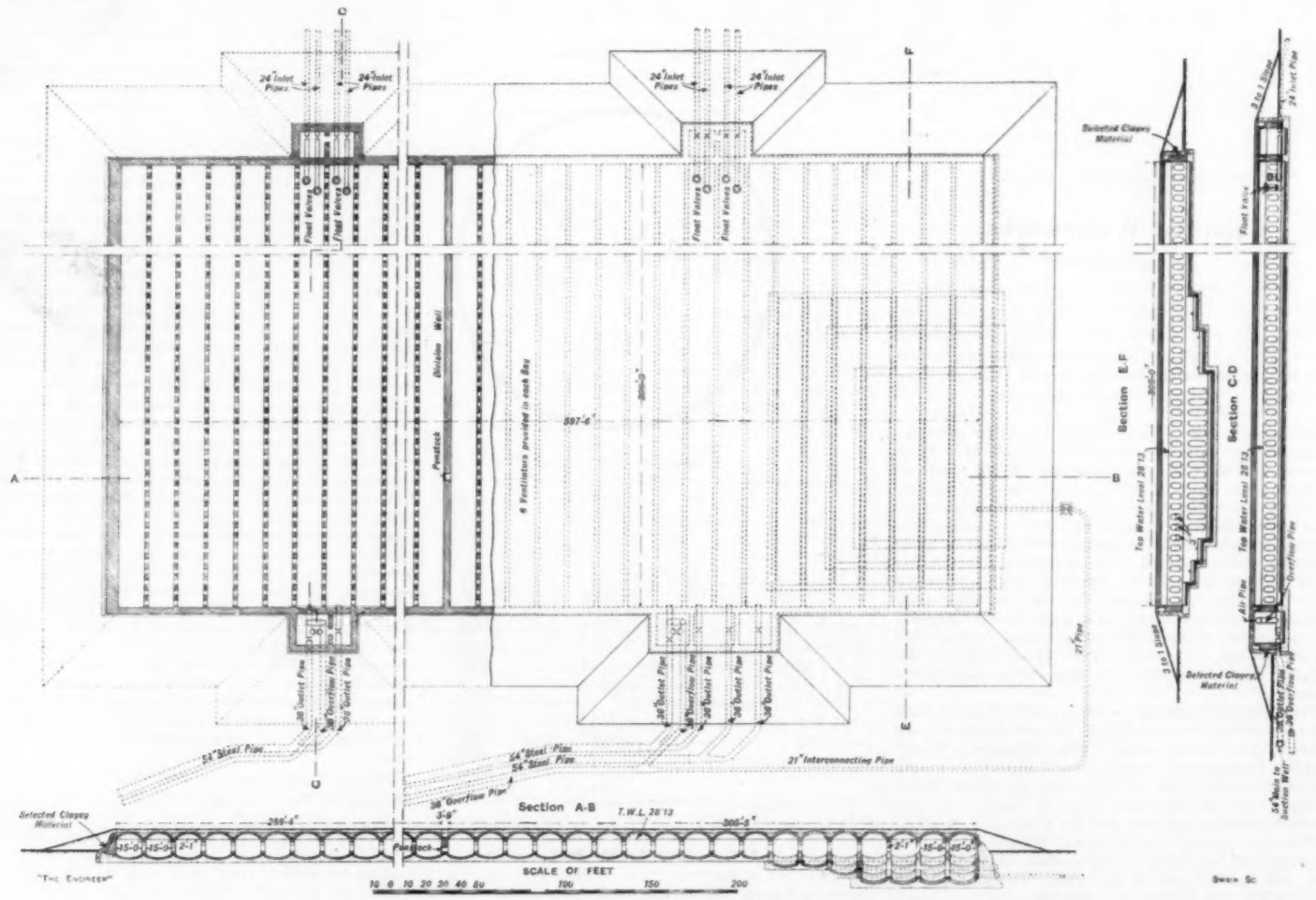


FIG. 10—RESERVOIR AT TALLAH. CAPACITY 10 MILLION GALLONS

Four Babcock and Wilcox boilers, fitted with mechanical chain grate stokers and Diamond soot blowers, and each having an evaporative capacity

which diminishes to 60in. about half a mile south of Tallah, now becomes part of the arterial main for Zone IV. Shortly after leaving Tallah pumping station the mains are carried under the sidings of the Eastern Bengal Railway and over a canal. A steel bridge carries the pre-existing 72in. main over the canal, and a new steel bridge, 100ft. span, has been built to carry the new 54in. and 45in. zone mains, as well as two 30in. mains. The bridge is supported at each end by piers formed of twelve steel piles, 6in. diameter, the screws being 3ft. 6in. diameter. The timber platform on each side forming the towing path rests on a steel framework partly fixed to the bracing of the piles. The pipes are fixed to cradles which are free to move on rollers.

The positions of the zones and the arterial zone mains are shown on the general plan, Fig. 1 *ante*. Each main is provided with a Venturi meter at Tallah.

In Zone I. the system of distribution piping is connected up to the 30in. arterial main at its termination at the zone centre. For Zone II. the 54in. main is laid as far as the zone centre, where it is reduced in diameter first to 48in. and then to 42in., connections being made with the distribution piping at the zone

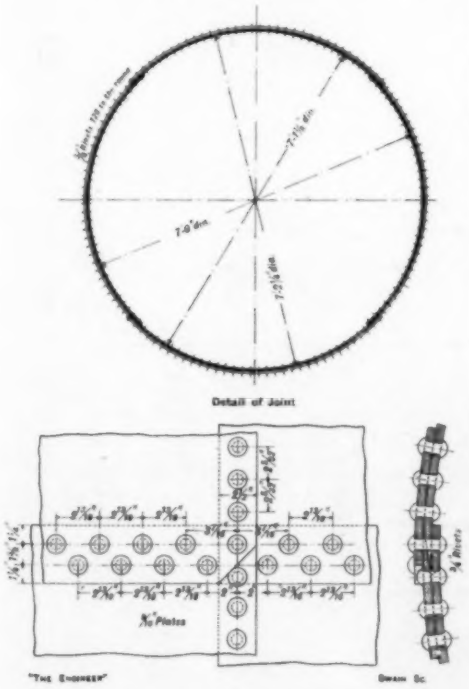


FIG. 13—STEEL CHAMBER AT TALLAH

centre, at the point where it is reduced to 42in., and at its termination. For Zone III. the 45in. main is laid as far as the zone centre, at which point the distribution piping is connected to it. Zone IV. comprises an area of about 14 square miles at the extreme southern end of the city. On account of its large area and the difficulty in reaching the western portion owing to the old and new docks intervening, an extensive system of mains leading from the zone centre has had to be adopted. The distance from Tallah to the zone centre is 5½ miles; for the first 3¼ miles the pre-existing 72in. reducing to 60in. steel main—which at present acts as the main distributor for the whole city—will be used as the arterial main, a new 60in. main being laid for the last two miles. From the zone centre, a main 39in. diameter, reducing to 33in. diameter, will be laid in a southerly direction and one 51in. diameter in a westerly direction. At a point on the latter about 1½ miles from the zone centre, a 42in. main 6 miles long will be laid to supply the western part of the zone and from the same point a short length of 33in. main continued on in a westerly direction. The distribution piping will be connected up at the ends of the 42in. and 33in. mains and at the point where the 39in. main reduces to 33in.

Cross connections are provided between the mains for Zones II., III. and IV. in case of emergency. Sluice valves are inserted at intervals of approximately one mile and at reductions in diameter, and inspection branches are arranged on each side of the valves, and wash-out branches taken off in suitable places. The pipes for the zone mains are of similar construction to the 60in. main from Pulta to Tallah.

The plates for 60in. pipes are $\frac{7}{16}$in. thick; for 54in., 51in. and 45in., they are $\frac{3}{8}$in. thick, and for all smaller sizes, $\frac{5}{16}$in. thick. The length from centre to centre of the circumferential joints for pipes from 60in. to 45in. diameter is 7ft. 1in., and for all sizes below 45in., 6ft. 0½in.

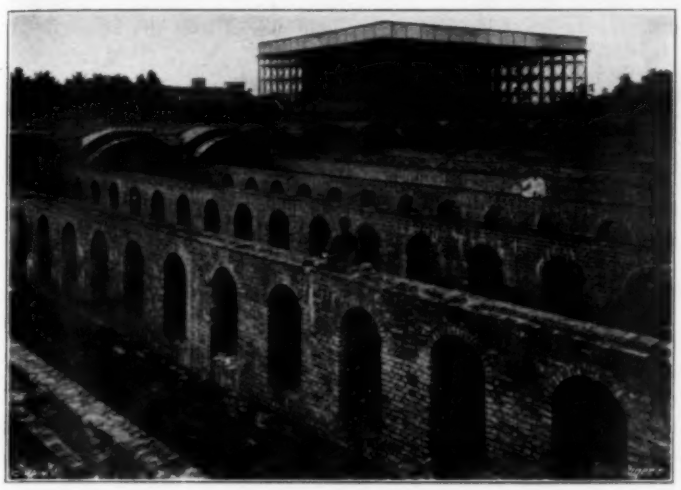
The bulk of the works at Pulta and Tallah has been completed, and the 60in. main from Pulta to Tallah has been laid. The arterial mains for Zones II. and III. are well advanced, but a considerable length of the arterial mains for Zone IV. has still to be laid.

Unfiltered Supply.

There are two pumping stations for unfiltered water, both of them situated within the city on the bank of the river Hooghly. One is named Mullick Ghat and the other Watgunge—see Fig. 1, *ante*. Mullick Ghat station primarily supplies the northern part of the city—with the exception of Cossipore-Chitpore—and Watgunge the southern part, but the piping for both parts is interconnected. In 1921 the plant at Mullick Ghat consisted of four vertical engines and pumps, which were erected in 1896, and each of which was capable originally of pumping 550,000 gallons per hour. The plant at Watgunge consisted of two compound horizontal surface-condensing engines and horizontal pumps, each capable of pumping 180,000 gallons per hour. The machinery at both stations was worn out and incapable of supplying the needs of the city, and it was imperative that new plant should be installed at the earliest possible date. Accordingly contracts were let to dismantle the old plants and to substitute electrically-driven centrifugal pumps.

Mather and Platt, Ltd., obtained the contract for the new plant at Mullick Ghat Station. It comprised originally four units each to deliver 625,000 gallons per hour, and two units each to deliver 312,500 gallons per hour against a head of 140ft. When the city boundaries were extended, an additional unit of 625,000 gallons per hour capacity was added, thus making the total seven units. Two of the larger units have been installed temporarily at the existing filtered water pumping station at Tallah, the other five units having been at work for some years. The total capacity of the seven units amounts to 90,000,000 gallons per day of twenty-four hours. The pumps are hydraulically-balanced and are direct-coupled to the motors, their speed being 970 revolutions per minute. The motors work on a three-phase alternating 6000 volt 50-cycle supply. The suction and delivery valves are electrically-operated and two air exhausters are provided for priming the pumps. The motors for the air exhausters and the valves work at a voltage of 220.

The four 30in. pre-existing suction pipes have been made use of, altered and inter-connected inside the engine-house so as to enable any pump or pumps to draw on any one or more suctions. At the river end of the engine-house, the two large delivery mains have been tapered to 18in. diameter and sluice valves have been fixed in them. Beyond these valves the mains have been cross-connected by an 18in. pipe. From this pipe branches with sluice valves attached connect with each suction pipe, thus enabling the latter to be flushed back into the river. In addition, a new 42in. suction pipe is being laid and connected to the system of piping inside the engine-house, the existing jetty being extended to accommodate the new pipe. Two 48in. delivery pipes, one on each side of the engine-room, and one 18in. delivery connect with a new 54in. main outside the engine-house on which is fixed a Venturi meter.



FIGS. 11 AND 12—TEN-MILLION GALLON RESERVOIR AT TALLAH UNDER CONSTRUCTION

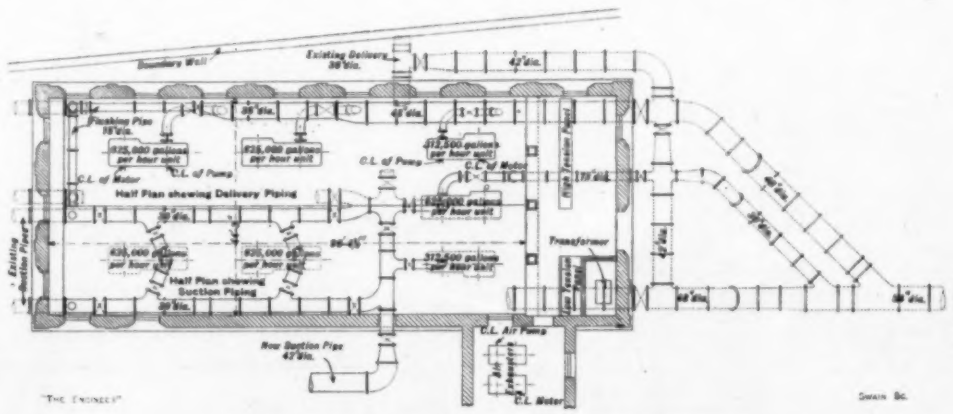


FIG. 14—PLAN OF MULLICK GHAT PUMPING STATION

Fig. 14 gives a plan of the new plant and piping.

Fig. 17, page 434, shows the inside of the engine-house looking towards the switchboards. In the foreground on the left are seen the foundations for the two units still to be erected.

Fig. 18 is a view of the inside of the engine-house looking towards the river.

To deal with the increased volume of water a new arterial main is being laid. It starts 54in. diameter at the pumping station, and is reduced to 45in. and 33in. diameter at the points where it is connected up to the existing system of distribution piping. A main 30in. diameter, branching off the 45in. main, is provided to supply the district to the east of the city, which was added when the boundaries were extended in 1923. The mains are of steel similar in construction to those for the filtered supply. For Cossipore-Chitpore, the most northern district added in 1923, a separate system of unfiltered supply is to be laid out by the Corporation.

The new plant at Watgunge pumping station was supplied by Worthington-Simpson, Ltd. It consists of six Worthington-Simpson centrifugal pumps, each designed to deliver 3500 gallons per minute against a head of 140ft., the total capacity of the station being, therefore, some 30 million gallons per day. The pumps are direct coupled to motors made by the English Electric Company, Ltd., the speed being 980 revolutions per minute. The current supplied to the station is a three-phase alternating 6000-volt 50-cycle supply, but the pressure is reduced at the station to 400 volts. The old pumps had one 30in. suction pipe terminating at a steel screw pile jetty on the river bank. This pipe has been retained, and, in addition, a new 30in. suction has been provided, the two pipes being cross-connected inside the engine-house. The original jetty has been extended to take the new pipe, the latter being laid in a brick culvert between the engine-house and the river retaining wall. The pumps deliver into a 42in. pipe laid centrally along the engine-house, a Venturi meter being inserted outside the house.

A new steel arterial main over three miles long is being laid to deal with the increased volume, and, except for a short length of 42in. diameter near the pumping station, it is 36in. diameter for its entire length. The construction of the pipes is similar to those for the filtered supply.

C. A. Parsons and Co., Ltd., are the main contractors for the new machinery at Pulta and Tallah filtered water pumping station; while the Cleveland Bridge and Engineering Company, Ltd., is supplying the 60in. main from Pulta to Tallah and the bulk of the steel arterial mains for both the filtered and unfiltered supplies.

The carrying out of the work in India is under the direction of Mr. J. R. Coats, M. Inst. C.E., Chief Engineer to the Corporation of Calcutta, assisted by Mr. N. B. Wilson, M.I.W.E., as Constructional Engineer, and Mr. B. N. Bhattacharjee as Resident Engineer.

The Hudson River Bridge.

A "First Progress Report" on the condition at the beginning of this year of the Hudson River Bridge, which is being built at New York between Fort Washington and Fort Lee, has just been made public by the Port of New York Authority. It is from the pen of Mr. O. H. Ammann, Chief Engineer of Bridges to the Authority, and it is prefaced by a short introduction written by Mr. J. E. Ramsey, the Authority's Chief Executive Officer. The Bridge is particularly noteworthy in that it is to be a suspension bridge with a span twice the length of any suspension bridge constructed up to the present time, and, as the matter is sure to be of interest to our readers, we give in the following article a general summary of that portion of the report which deals specially with the design of the bridge. In many cases, we quote verbatim from the report.

The Bridge is being built by the Port New York Authority, which is a body created by compact made between the States of New York and New Jersey, and ratified by Congress. Its position, which is indicated on the map, Fig. 1, is defined by the Legislative Acts of the States of New York and New Jersey as being "between 170th and 185th Streets in Manhattan, New York City, and points approximately opposite thereto in the borough of Fort Lee, New Jersey." The site is described as being well chosen for a bridge crossing with respect to both the topography and geological conditions. The ground on both sides of the river in its vicinity rises to a height of 200ft. and more, which permits of short and comparatively inexpensive approaches. There is a marked traffic demand in the neighbourhood, and it is feasible to connect the bridge with important highway arteries on both sides of the river Hudson.

We need not follow the report through the description of the preliminary stages through which the project passed from the inception of the idea to the starting of constructional operations; nor is it necessary to do more than refer to the extensive researches—geological, mathematical and engineering—which it was necessary to carry out. It will suffice to say that in May, 1927, a contract was entered into for the construction of the foundations of the New Jersey tower, and that work on that portion of the structure was begun immediately afterwards. The building of the two large open cofferdams, enclosing the foundation site proceeded steadily to schedule, and was completed by the end of the year. The placing of the concrete for the foundations proper was under way at the time the report was written, and it, too, was expected to be finished within schedule time. In June, 1927, a contract was entered into for the rock excavation for the New Jersey Anchorage and approach, and work under that contract has been proceeding satisfactorily since. In the following October, after three months' preparatory work by the manufacturers, tenders were received for the fabrication and erection of the entire steel work of the main bridge, embracing, approximately, 100,000 tons of steel. Orders for the material were given ten days later, and, since then, elaborate preparations for the fabrication have been in progress, while before the end of the year the rolling of steel for the towers had been started.

It was necessary that the bridge piers or abutments

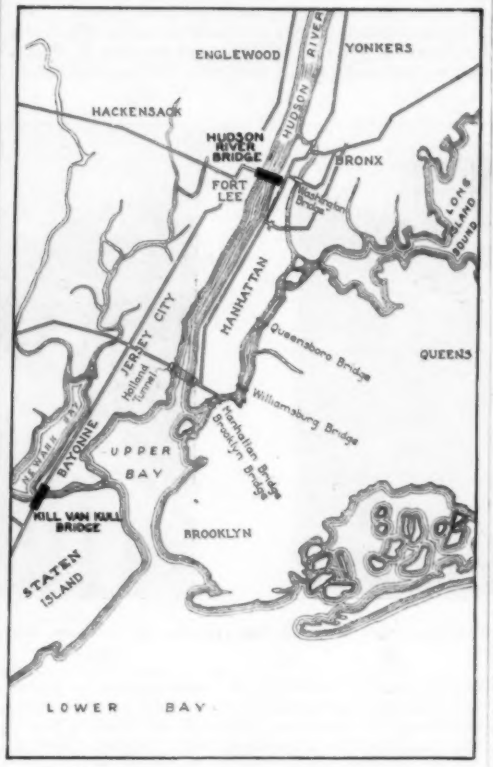


FIG. 1—MAP SHOWING POSITION OF BRIDGE

should come within the pierhead line established by the United States War Department, which controls all waterways, and, as any intermediate pier or piers were inadmissible, that entailed the construction of a bridge with a single span of the unprecedented length of 3500ft. between centres of towers. That length is just double the corresponding figure for the Delaware River Bridge,* which, at the present moment, is the longest single-span suspension bridge in the world. A profile and plan of the Hudson Bridge are given in Fig. 4; while a cross section is given in Fig. 2, and for purposes of comparison a cross section of the Delaware Bridge is given in Fig. 3. The total length of the new bridge between abutments or anchorages will be approximately 4800ft.

The elevation of the bridge floor, as determined by the height of the connecting streets on both sides of the river, will be 253ft. above water level, and there is to be a clear height of 195ft. above mean high water at the towers, and of 213ft. at the centre of the bridge under normal temperature conditions and without load. It is calculated that, with a combination of extreme high temperature and a full load—a condition which, the report remarks, is not likely ever to occur—the floor would sag to 203ft. in the clear at the centre. For the sake of comparison the report points out that the five East River Bridges in New York have each a clear height of 135ft. for a width of channel of 400ft., decreasing to from 114ft. to 126ft. at the pierhead lines. The Delaware River Bridge at Philadelphia provides a clear height of 135ft. for a width of 800ft.; the St. Lawrence River Bridge at Quebec has a clearance of 150ft., for a width of 600ft.; while the Sydney Harbour Bridge is to have a clear height of 170ft. for a width of 600ft. The Hudson Bridge will, it is claimed, have ample height for the passage beneath it for the largest vessels which are likely to go up the river beyond it.

A fair conception of the size and proportions of the new Bridge may be formed, says the report, by the following comparison with the Delaware River Bridge:—

	Hudson.	Delaware.
Length of river span	3500ft.	1750ft.
" side span	650ft.*	750ft.*
Total length between anchorages of bridge and approaches	4800ft.	3253ft.
	7800ft.†	8240ft.†
Clear height above water	200ft.	135ft.
Height of towers above water	635ft.	380ft.
Width of bridge floor over all	118ft.	125ft.
Traffic capacity—		
Footways	2	2
Road lanes	8	6
Electric railway tracks	4	4
Total traffic lanes	14	12
Weight of suspended superstructure, tons	90,000	40,000
Strength of carrying cables, tons	350,000	120,000

* Centre to centre of cable saddles.
† Between plazas.

Discussing the length of the span, the report remarks that "engineers familiar with the design and construction of large bridges have pointed out that the feasibility of building a bridge of as long a span as 3500ft. and more, is essentially a question of economy, and that the span length and size of a bridge has nothing whatsoever to do either with its safety either during erection or after completion. The feasible limit of span is reached when the amount of metal required to carry a given load becomes excessive in cost, and not because the safety is impaired. The physical limit of span is reached when no amount of metal can safely carry more than its own weight. The latter limit can be mathematically determined for the safe strength of any given material, and has been calculated by various authorities at 10,000ft. and more."

In the conception and development of the bridge, the guiding motives, from an engineering point of view, have, says the report, been purity of type, simplicity of structural arrangement, and ease and expediency of construction, those motives being compatible with true economy, greatest safety and utility, and with good appearance. A controlling aim in the development of the design was to permit of a later enlargement, or increase in capacity, of the bridge and its approaches after its initial opening to traffic.

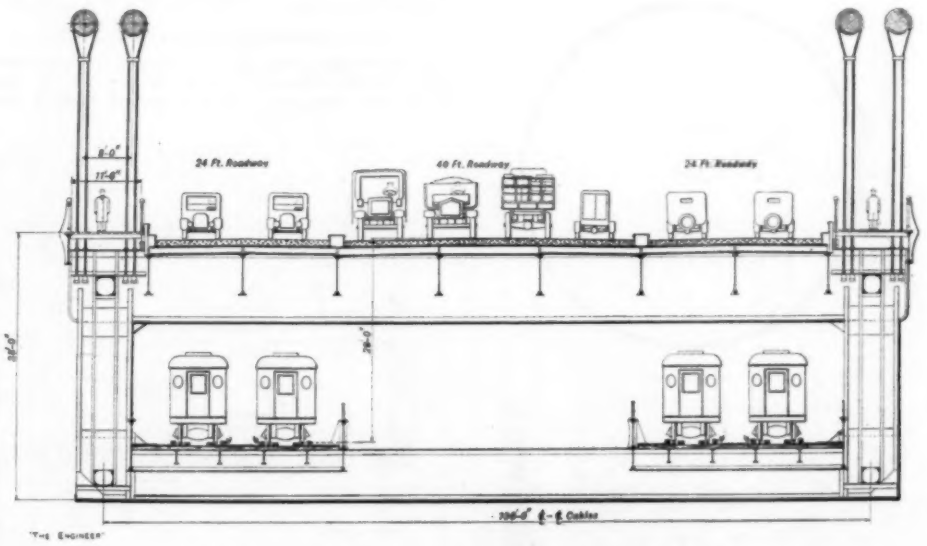


FIG. 2—CROSS SECTION OF THE HUDSON RIVER BRIDGE

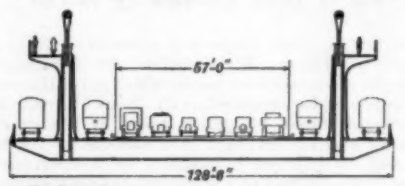


FIG. 3—CROSS SECTION OF DELAWARE BRIDGE

The loads and forces which will act on the bridge are so complex, and attain such magnitude, that they had to be most carefully considered with a view

* Described in the issues of The Engineer for February 25th, March 4th, 18th and 25th, and April 1st, 1927.

THE NEW BRIDGE TO BE BUILT OVER THE RIVER HUDSON

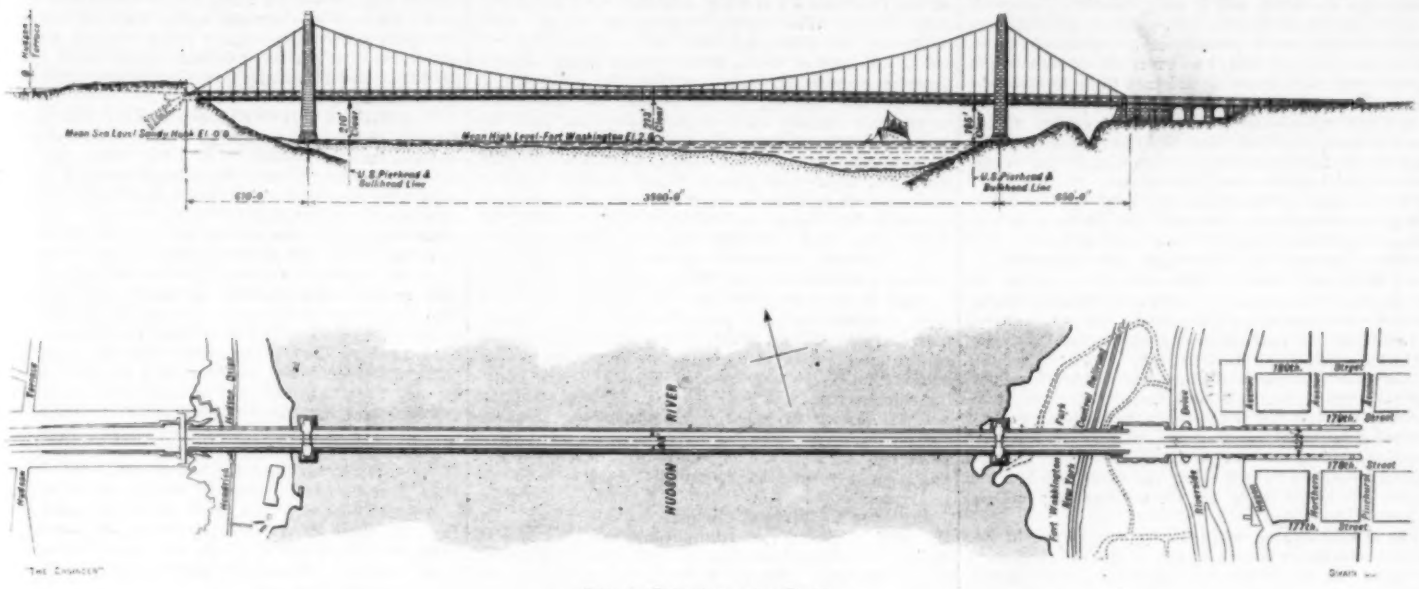


FIG. 4—PROFILE AND PLAN

to secure ample safety against any combination of forces which, under reasonable assumptions, appeared possible. Fortunately, we are told, the problem was greatly simplified by the facts that the structure and its stress action are simple, and, further, that the deadweight, which can be accurately determined, is the predominant force. The other forces, such as moving loads, impact, wind, temperature, &c., being relatively small when compared with the dead load, uncertainties as to their magnitude and effect are much less significant than in smaller, relatively lighter, structures. The dead load of the suspended span will, in the average, be 39,000 lb. per linear foot in the centre span, and 40,700 lb. per linear foot in the side spans—or from four to five times the greatest live load which is ever likely to move across the bridge.

In the proportioning of parts of the structure which will be affected by individual load concentrations, the heaviest existing vehicles were assumed, and liberal allowances were made for possible future increases and for impact effect produced by vehicles moving at high speed. There are to be no restrictions as to speed, except such as are advisable for the safety of traffic.

Consistent with increased distribution and variety of load units, and their decreasing compound impact effect, the intensity of the assumed load and its impact effect was, by appropriate and convenient formulæ, reduced, both with increasing length of load and with increasing number of load lanes which produce the greatest stresses. The roadway flooring has been proportioned for a 25-ton truck with 75 per cent. impact, which corresponds to an average of 440 lb. per square foot of floor space, or 4400 lb. per linear foot of lane. For the 60ft. roadway stringers, affected by a single lane of traffic, the load with 58 per cent. impact is 324 lb. per square foot, or 3240 lb. per linear foot of lane. For the roadway floor beams, which carry two 60ft. panels and eight lanes of vehicles, the load with 17 per cent. impact is 140 lb. per sqaure foot, or an average of 1400 lb. per linear foot of lane.

For the cables, towers and anchorages, which get their maximum stress from load on the entire bridge, and for which impact is negligible, the live load was assumed at 8000 lb. per linear foot of bridge. This figure corresponds to a live load composed of 10-ton transit trains, one train length apart, on all four railway tracks on the lower floor—a load condition, which, it is anticipated, is not likely ever to occur.

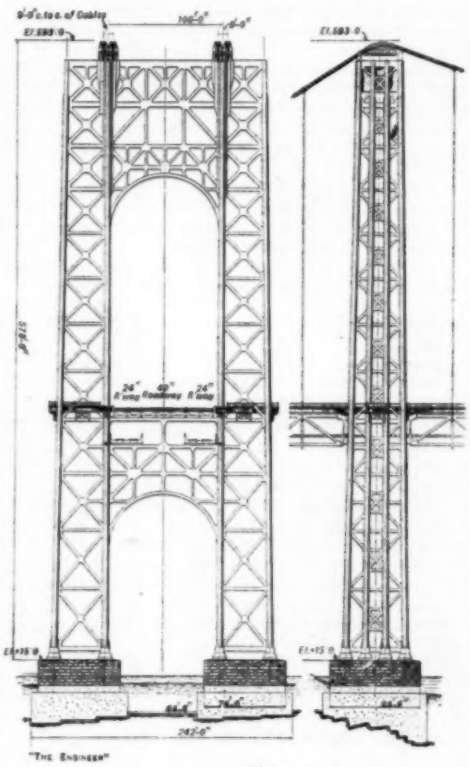


FIG. 5—ELEVATIONS OF TOWER STRUCTURE

For proportioning the main lateral or wind bracing along the floor, and of the towers, a wind pressure of 1500 lb. per linear foot of bridge was assumed, and suitable allowance was made for the fact that a portion of the floor wind force will be transmitted to the floor brackets cantilevered out from the verticals of the trusses. Subsequent investigation showed, however, that a single floor beam between the trusses,

cables, and by them carried to the tops of the towers. A maximum change of temperature of plus or minus 55 deg. from normal, was used as a basis for calculating stresses set up in the structure by temperature changes, and a change of 75 deg. from normal was assumed in allowing for temperature expansion.

As will be observed in Fig. 2 the floor structure is to comprise two decks, of which the upper is to serve vehicular and pedestrian traffic exclusively, while the lower will be reserved for rapid transit traffic. The floor structure is simple. In each deck single-span floor beams, 60ft. apart, suspended at their ends from the cables, will carry the longitudinal floor stringers, which, in turn, will support the flooring. The upper floor will be divided into two outside roadways, each 24ft. wide, a central roadway 40ft. wide and two footways. The central roadway is to accommodate four lines of traffic of the heaviest type, and it has been proportioned to carry, safely, trucks of 25-ton weight, moving at fast speed. Each of the outside roadways will conveniently accommodate two lanes, and, in an emergency, or intermittently, three passenger cars side by side. They will be proportioned for vehicles not in excess of 15 tons, moving at high speed.

The central roadway and the footways are to constitute the initial capacity of the bridge. Studies of the traffic likely to use the bridge indicate that that provision will be sufficient to meet the demand for at least five, and possibly for ten years after the opening of the bridge, since the structure, as initially to be built, will be capable of accommodating a yearly traffic of from 12 to 15 million vehicles. It is intended to erect the outside roadways, which will probably be required before 1940, at a later date.

Approximately 38 per cent. of all the material in the floor system will be structural carbon steel with a minimum tensile strength of 58,000 lb. per square inch; 56 per cent. will be silicon steel, with a minimum tensile strength of 80,000 lb. per square inch; and 6 per cent. will be nickel steel with a minimum tensile strength of 90,000 lb. per square inch. The respective basic permissible unit stresses in tension are 20,000 lb., 27,000 lb., and 33,000 lb. per square inch respectively.

In the preliminary design for the lower deck of the bridge, the four rapid transit tracks were carried on

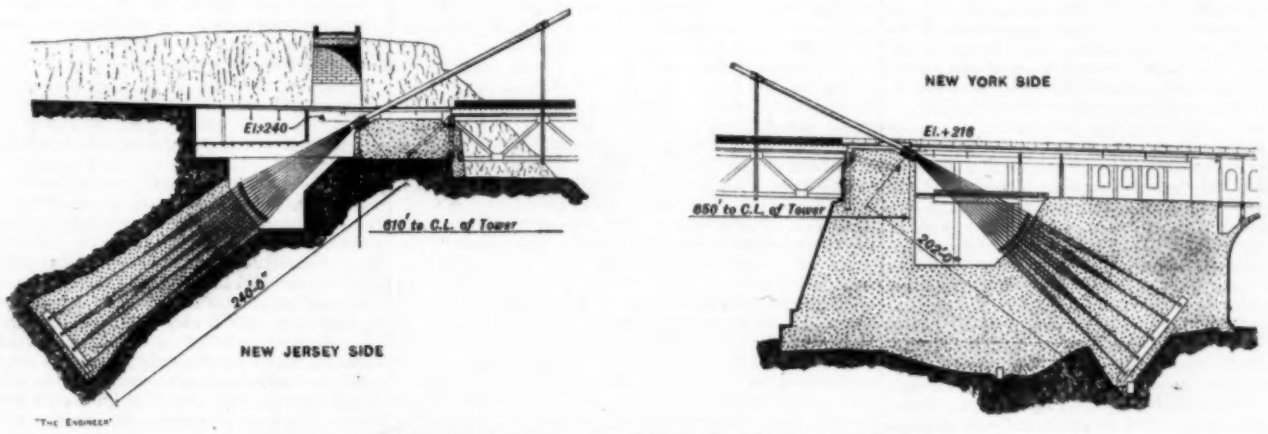


FIG. 6—ARRANGEMENT OF THE TWO ANCHORAGES OF THE BRIDGE

vehicles spaced, on an average, 50ft. on centres, or 5-ton vehicles spaced 25ft. on centres, on all eight roadway lanes on the upper floor, and heaviest rapid

independent of the upper deck, possessed sufficient advantages to justify the comparatively small additional cost involved, and it was, therefore, adopted. It has, the report points out, greater flexibility in traffic capacity, as it permits of the addition, later, of not only two or four, but even six or eight rapid transit lines. The lower deck is not to be built at the outset, but is to be erected after the opening of the bridge for initial capacities. Consideration of the possible traffic indicate that the demand for it may arise within ten years after the opening of the bridge for vehicular traffic—possibly earlier.

For the sake of structural simplicity and to avoid ambiguous distribution of load, the cables and suspenders will be arranged in two vertical planes, and the floor frames will, therefore, be suspended at two points only, one on each side of the floor. In the planes of the suspenders the cables will hang almost perfectly free except in so far as they will be restrained in their vertical and horizontal deformations under load by the relatively flexible floor. The great weight of the cables themselves and that of the floor suspended from them, will lend them ample stability, and there is not the necessity to provide as rigid a stiffening as that required for smaller and lighter suspension bridges. In fact, the relatively shallow stiffening trusses placed along the floor between the upper and lower deck are an outstanding characteristic of the design.

The horizontal or wind stiffening system in the plane of the upper floor, the chords of which will form the upper chords of the vertical trusses, while amply rigid to resist the heaviest wind pressure, is, likewise, comparatively flexible, with the result that, in deflecting, it will produce effective counteraction by the heavy suspended cables, and is, thus, relieved of a large part of its wind load with, consequently, a marked saving in metal and cost. The members of the stiffening trusses will be partly of carbon steel, and partly of silicon steel. The permissible stresses are the same as in the floor system.

The catenary formed by the cables in the centre span will be a relatively flat and graceful curve, the sag at the centre being only 325ft., or about one-eleventh of the span length. In the side spans, owing to the short length of the latter, the catenary will only be slightly curved, and will fall at a steep angle towards the anchorages.

From the inception of the project it was realised that two types of cables, which could compete economically, were available, namely, (*a*) that composed of high-tension drawn steel wires, and (*b*) that composed of high-tension heat-treated forged eye-bars. Both types have reached a high degree of perfection in American bridge construction, and both make excellent and safe tension members for suspension bridge cables. The question of selection of which type to employ became, therefore, essentially one of cost. In the tenders received wire cables proved to be the lower in cost, and, upon the unanimous recommendation of the staff and the consulting engineers, they were selected by the Port Authority.

The adopted design for the bridge provides for two pairs of cables, one pair on each side of the floor. The cables of each pair will be erected, successively, side by side. Each cable will be 3ft. in diameter and will be composed of sixty-one parallel strands, of, approximately 4¼in. in diameter. Each strand will contain 434 No. 6 galvanised steel wires, 0·196in. in diameter, so that each cable will be composed of no less than 26,474 wires with an aggregate cross-sectional area of some 800 square inches.

The cables are to be tightly wrapped with a layer of 0·148in. diameter galvanised wire, and each cable will have to sustain a maximum pull of 65,400,000 lb., or at an average rate of 82,000 lb. per square inch of metal. The material of the wires is specified to be manufactured by the open-hearth or the electric furnace process, and to have an average minimum strength, when tested after galvanising, of 225,000 lb. per square inch. Each cable will, therefore, have a strength of 180,000,000 lb.

It was originally intended that only one pair of cables—one on each side of the floor—should be erected in the first instance. Consideration of matters, however, led to the decision that the initial roadway for four-line vehicular traffic might have to be enlarged soon after the opening of the bridge, and it was therefore thought best that all four cables should be got into position before the bridge was opened.

The cables will terminate at each end in eye-bar anchor chains, the various branches of which will be spread out so as to engage and be embedded in the requisite mass of rock or masonry which has to resist the pull of the cables. These anchor chains are to be in four separate units, one for each cable. On the New Jersey side, they will be anchored in the hard trap rock which forms the cliff—see Fig. 6. On the New York side they are to be anchored in an almost solid block of masonry about 290ft. by 200ft. at its base and 290ft. high resting on bed rock. The anchorage of each cable will be composed of 122 lines of eyebars, 10in. wide by 1¾in. to 1⅞in. thick. They will be of heat-treated carbon steel, and will have an average minimum tensile strength of 85,000 lb. per square inch, and an average minimum yield point of 53,300 lb. per square inch. The maximum theoretical stress is 30,000 lb. per square inch.

The towers are to be specially massive in order to be in keeping with the monumental character of the structure as a whole, and to be in harmony with the surrounding scenery, especially with the rock face of the Palisades on the one side and with the rocky point of Fort Washington Park on the other. Each tower will be 210ft. by 65ft. at the base, and will reach a height of 635ft. above water, being slightly tapered towards the top—see Fig. 5. In order to expedite the opening of the bridge, the towers are to be built initially as steel skeletons, but, after the opening of the bridge for traffic, these skeletons will be embedded in a concrete casing faced with granite, the steel, stone and granite being bonded together to form a monolithic mass. The steel skeleton will, however, be strong enough to carry, of itself, the entire dead and live load of the completed structure. The main columns of the tower will be of silicon steel and carbon steel will be generally used for the bracing and its connections. The silicon steel is to have a minimum yield point of 47,000 lb. per square inch and a minimum tensile strength of 80,000 lb. per square inch. The maximum stress in the lower columns for a combination of greatest axial and bending stresses from full load of the completed structure will not exceed 27,000 lb. per square inch. For the completed upper deck, the stresses will not exceed 22,000 lb. per square inch, and the greatest average axial stress in all columns will not exceed 20,000 lb. per square inch.

Both towers will rest on solid, hard bed rock. On the New York side, no foundation work is required, saving surface preparation, as rock is available above the water line. On the New Jersey side, however, solid rock was only reached at a depth of from 35ft. to 75ft. below water level. On that side, each of the two tower legs will rest on a solid base measuring approximately 100ft. by 90ft., which is being built within a cofferdam. This foundation method, remarks the report, although exceptional in size and depth, presented no serious construction problems, and permitted of thorough examination and preparation of the rock surface.

At the New Jersey end the bridge roadway will strike the face of the Palisade Cliffs about 50ft. below the top of the latter. From there it will rise with a 4 per cent. gradient in an open rock cutting to the Plaza at Lemoine Avenue, about 2000ft. distant. On the New York side the roadway will descend on a 2·2 per cent. gradient from the bridge abutment or anchorage on a viaduct which will reach the surface just west of Pinehurst Avenue, thus forming an approach only about 1000ft. long.

According to the report the following quantities are involved in the construction of the bridge :—

Excavation	400,000 cubic yards
Concrete	465,000 ,, ,,
Stone masonry	57,000 ,, ,,
Steel work, structural	120,000 tons
Reinforcing steel	10,000 ,,

The original estimate of the cost of the bridge for initial capacity was 50 million dollars. Owing to the decision, referred to above, to increase the initial capacity, that figure was increased to 60 million dollars, or, say, £12,000,000. When necessary, and if additional revenue will justify it, the bridge may be enlarged to full capacity by the expenditure of, approximately, an additional 15 million dollars.

The bridge is to be a toll bridge, and, on the assumption that it is completed in 1932, it is anticipated that in twenty-two years, that is to say, in 1954, the net revenue will be 13,500,000 dollars, and that the original outlay will have been refunded.

The Revolution in Physics.*

By Sir OLIVER LODGE.

The nineteenth century came to a climax, as far as physics is concerned, in the discovery of the discontinuous nature of electricity and the isolation of the electron. It turned out to be a natural unit of electric charge, of specified size and mass, and with a measurable momentum and energy when propelled by a given drop in voltage. The same electric units were obtained from every kind of atom, irrespective of its chemical nature; and they were proved by Zeeman to be the particles which generated radiation. Their impacts when suddenly stopped in a vacuum tube were indeed found to generate a new kind of radiation called X-rays. Their whole mass corresponded with an electric charge of a given size, in accordance with the theory formulated by Sir J. J. Thomson so long ago as 1881. They had no matter associated with them, and at very high speeds their mass increased with the speed, in a way which was calculated from purely electric principles by both Oliver Heaviside and Sir J. J. Thomson. In fact, a great deal seemed known about them.

Some of this knowledge remains valid; but the twentieth century has so far succeeded in putting everything back into the melting pot, and reducing the electron itself to a curious state of uncertainty, an uncertainty which always existed as to its nature and constitution. Electrons may still be treated as structures in the ether, of an unknown kind; but no longer can their size and shape be specified with the same certainty as seemed legitimate at the beginning of the century. The way they produce energy has been worked out in great detail by Bohr on the assumption of unexplained quantised orbits, in which they can remain stable without radiation, but from which they cannot jump without emitting radiation, of a perfectly definite kind, which can be predicted arithmetically and accurately verified by spectrum analysis.

Very little of this was known to Lord Kelvin, who died in 1906; and probably no suspicion of it had dawned on Clerk Maxwell, who had died some years before. I doubt if even FitzGerald grasped the consequences which have followed from the discovery of this curious discontinuity in electricity. And now some uncertainty has entered into our views as to the constitution of the electron itself; and Schrödinger adduces evidence to show that they are not so much like particles or corpuscles as like a train of waves. The simplicity of the wave theory of light has been complicated into a kind of corpuscular theory by the quantum; while at the same time the corpuscles themselves are being resolved into waves. All this is very puzzling, and at the same time very interesting; and for the complete solution the present generation will have to wait.

Meanwhile, and temporarily, the Ether of Space has suffered from the same kind of doubt. It is argued that if radiation is something shot out in quanta, it may be shot out into perfectly empty space, and that the need for an etherial vehicle of communication has disappeared. I do not agree, for a great many reasons. But all theories are being overhauled, and the end is not yet.

Lord Kelvin would have been no doubt keenly interested, and would also have been very much perturbed, by the present state of physics, which is full of hypotheses that would have seemed to him wild, and which certainly are of a revolutionary character. The mathematical methods employed are of a novel and undynamical kind, very different from the methods which dominated the nineteenth century and were so successful in dealing with the then known properties of matter. With the ether, however, those methods did not satisfactorily deal. Something apparently inexplicable intervened, directly the ether was brought into notice. There was a puzzle as to how ether and matter interacted as well as about a possible constitution for the ether itself. Both Lord Kelvin and G. F. FitzGerald made many attempts at a dynamical ether; that is to say, they sought to explain the properties of the universal medium in terms of mechanism, constructing or imagining mechanical models which would have something the same sort of properties, and would give or suggest a possible constitution for an electro-magnetic medium. They aimed at thus explaining the phenomena of electricity, magnetism, and light, though they did not attempt to introduce gravitation into their scheme, and on the whole they failed. The ether regarded as an elastic solid had a long day, and at one time promised well, but sooner or later it always collapsed. Its contradictory properties could only be reconciled by special pleading; and at length we all came reluctantly to the conclusion that the ether could not be explained in terms of mechanism. We began to think that the laws of dynamics would not apply to it. Newtonian laws were sufficient for ordinary matter, but even here they could hardly be extended to cover special cases, when extreme velocities, or even extremely low temperatures, were encountered. Discontinuities began to make their appearance, not only in electrical phenomena and in radiation, but even in matter itself near the absolute zero of temperature. Mechanical theories of the ether had to be abandoned; and this is what is meant, or should be meant, by the statement that "the ether no longer exists." The arguments for an ether of some kind are as valid now as they ever were; and Einstein himself has devoted three lectures in a little volume, entitled "Sidelights on Relativity," to claim the physical necessity of an ether, in order to enable the new equations to be interpreted in physical terms. The characteristic constant of the modern ether is the constitutional velocity *c*, which is the same order of magnitude as the velocity of light; and that constant *c* dominates the present situation.

In trying to expound in some elementary fashion some salient features of the present position, I shall aim at being as conservative as I can. I shall not attempt to enter upon the most recent forms of wave theory, but shall limit myself to views which have instinctively commended themselves to me, and, what is more important, commended themselves also to some extent to that great man who has recently parted from us, H. A. Lorentz. They have also received attention and been partly elaborated in detail by Poincaré and Langevin. I think it highly unlikely that my hypothesis about the structure of an electron is anything like finally correct; but sometimes a position may be helpful as a stepping-stone, although it has soon to be discarded. And it may be worth while to make some statements about the ether and about the possible structure of an electron, even in face of the hostile criticism which they will doubtless encounter, and the contention that they are already superseded.

In addressing an assembly of electrical engineers, I would remind you that electrons are what this Institution specially deals with. In one form or another they are what you harness, drive, and utilise,

* Abstract of Kelvin Lecture delivered before the Institution of Electrical Engineers.

and it is only natural to wish to know what sort of things they are. You have had these active little creatures harnessed for some time, and have propelled many things by their aid, from telegraphic messages to railway trains. But you have never been allowed to see them, even metaphorically. They are cloaked; so that we are like a costermonger with a shrouded animal between his shafts, who does not know whether it is a dog, a zebra, or a donkey. He can only infer its nature from its more or less tractable behaviour. And certainly electrons have proved themselves not only very active, but very tractable, very obedient to the smallest guidance, and yet very energetic. We can readily drive them along wires, but then we cannot count them, and do not know at what pace they go. It is rather odd that even now we have something less than full and complete knowledge of all that happens when you press the button of an electric bell.

The first mode of propelling them, devised at the beginning of last century, was to coax charged atoms to move through a liquid by a differential chemical attraction; that is, by the greater attraction of zinc for oxygen than was possessed by copper or carbon. The charges were thus conveyed through the liquid, and delivered up to the electrodes at either end, whence they went of their own accord through the wire joining the plates, with an energy derived from the chemical action, which thus took the primary form of an electric current, instead of heat.

Then Faraday made the extraordinarily fruitful discovery that they could be propelled by moving a magnetic field near the wire of a metallic circuit, a method which soon eclipsed the older method in power, and made heavy engineering possible. This, however, was almost a more blindfold method than the older chemical one; for now the atoms did not move, in any part of the circuit; they seemed to pass the electrons from hand to hand, whereas in the liquid part of a telegraphic circuit electrons clung tenaciously each to their own atoms, and were conveyed by the atoms or carried the atoms along with them. Only in a vacuum were we able to shoot them off from a metal, and get them to travel on their own account, divorced from any form of matter—as was first emphasised by Sir William Crookes—in such a way that their speed and other peculiarities ultimately yielded to the penetrating insight of Sir J. J. Thomson and his co-workers.

Then it was found by Hertz and Lenard that it was possible to shoot them out into the open air; while Becquerel made the important discovery that the atoms of certain heavy substances shot them out on their own account without any stimulus. At the same time an experiment, first made by Guthrie, and then developed extensively by Professor Richardson, showed that they evaporated freely from hot metals, and were subject to control, as in the familiar vacuum valves of to-day.

It was also found that high-frequency radiation was able to expel electrons from certain substances, with an energy exactly proportional to the vibration frequency of the light or other radiation which expelled them; though why this proportionality should exist between energy and frequency in all cases and for all substances, as was finally demonstrated by Max Planck, I doubt if anyone is fully prepared to say. There is evidently something deep-seated in atomic structure here, which when properly understood will account for this relation, and for the reciprocal fact that the speed or energy of a flying electron determines the frequency of the light which it emits when stopped. Meanwhile, the study of radiation, or the interaction between matter and ether, has resulted in the discovery of the quantum that remarkable natural constant, which bids fair to revolutionise the whole of physics, and in due time must undoubtedly throw light on the connection between ether and matter. Suffice it to say here, in the words of Professor Whittaker, expounding the view of H. A. Lorentz, with which in all major respects I agree:—

> "The essential characteristics of Lorentz's theory were that all electric, magnetic, and optical phenomena were supposed to be due to the presence or motion of individual electric charges, constituting the link between ponderable matter on one hand and the ether on the other. Matter and ether were supposed not to interact directly, and to be capable of influencing each other only through the mediation of electrons; moreover, the electrons were assumed not to interact directly (as they had been supposed to do in the older electron theories), and to be capable of influencing each other only through the mediation of the ether. The ether itself was conceived to be at rest everywhere and at all times, whereas in the earlier theories it had been regarded as entangled with the particles of bodies, and carried along with these when they move. Lorentz's ether was, in fact, merely space endowed with certain properties. The general plan of the investigation was to reduce all the complicated cases of electric and magnetic action, *e.g.*, the properties of dielectrics, metallic conduction, metallic reflection, the Hall effect, &c., to one simple and fundamental case, in which the field contained only free ether with electrons at rest or moving in it."†

† *Nature*, February 25th, 1928, Vol. 121, p. 290.

Parenthetically, I call attention to the sentence in this paragraph: "Lorentz's ether was, in fact, merely space endowed with certain properties." That also I take to be the view of Einstein, and I find no fault with it. The ether is synonymous with what we call empty space, except that it is by no means empty; it is only empty of matter. It is space with physical properties, it is space become substantial; it is no longer merely geometrical space. It is a plenum able to be treated physically, and no longer a mere subordinate interval furnishing room to move about in. It is able to do things, to transmit vibrations, to be the seat of electric and magnetic and gravitational fields; it is amenable to law and order, and is able to satisfy certain equations. It has constants that can be determined; and when we have more knowledge I believe that it will be amenable, not only to calculation, but to experiment too. At present it is elusive, and some therefore think it illusory. But although we have no means of getting at it in any satisfactory manner at present, it would be a mistake to try to shut the door to further inquiry, and to deny its existence, merely because we do not see how to explain its properties. If we like to call it "space" instead of "ether," there is no objection; but remember that it is space with physical properties, and all physical properties are legitimate subjects for physical inquiry.

To return from this digression. Then came the remarkable experiments of C. T. R. Wilson, whereby in a sense he may be said to have rendered both atoms and electrons visible, at least when flying at high speed, by the streak of condensed vapour which congealed round the path of the travelling charge. True, the particles themselves are not visible, but their residual effects are; that is, the residual effect of each single particle. Under these circumstances, it is almost a matter of words whether we say we can "see" the particles or not when we look at their individual streaks. For what does it mean when we say we "see" an object? All that we get from it is certain ripples in the ether, which enter our eye. From that, by long practice, we infer the object. Looking at waving branches we infer a wind. Looking at a moving needle, we infer a current. Looking at a mist, we infer the globules of which it is composed, or even the nuclei round which those globules are condensed. Looking at the movements of a column of mercury, we infer a rising or a falling temperature or even a coming storm. Innumerable things in physics are not give us by direct observation, but by indirect inference.

So it is with electrons and atoms. So it is also, I venture to say, with the ether. Professor Eddington had an ingenious illustration of this use of language when we say that we "see" something. He pressed his thumb on a photographic plate and developed the impression. Anyone shown that plate would probably say, not that it was a smudge, but that it was a human thumb; and a finger-print expert might be able to say after examination that it was Professor Eddington's thumb. In that same sense when we "see" C. T. R. Wilson's streaks of condensed vapour we can say that we see the track of an electron or an atom or an ion. We can see their track, or at least minute drops congealed along that track, but we are far from seeing or knowing the shape and structure of the things that produce the congelation. Is there any way of learning anything about them?

The arrangements of atoms in a molecule, which at one time could only be determined by the remarkable instinct of chemists, is now being made almost visible by aid of X-rays and the patterns which they produce after passing through or among such molecules, thereby supplementing and often confirming the previous blindfold, though brilliant, anticipations of chemists. Long immersion in phenomena develops a wonderful insight. Going on still further, the arrangements of electrons in an atom have now been almost rendered visible to the mind's eye by the genius of Bohr and his co-workers, with detailed additions due to Sommerfeld and others.

Is there any way of arriving at the shape and transformations of an electron? I suppose not yet. But still I have thought in that direction, and have been impressed with the work of Poincaré and Langevin; and though I fully expect to be told that I am somewhat out of date, and though it may be a mistake to hark back to what I wrote some years ago, especially in these days when progress is so rapid, though perhaps not so secure, that anything a year old is sure to be superseded, I will venture in this Kelvin Lecture to call attention to these comparatively antiquated ideas, in the belief that even what has been discarded may contain some features which are instructive, and even possibly a few features which are true.

Let me hark back therefore to the only quasi dynamical theory of the ether which seems likely in any degree to survive, or perhaps to be revived only by posterity, namely, the hydro-dynamical ether or perfect incompressible fluid in vortex motion—the fine-grained rotational structure or vortex sponge, which was worked at both by Kelvin and G. F. FitzGerald. I may in a note or appendix give a kind of summary of the lines of this mathematical investigation, which confessedly is not entirely satisfactory, but which, nevertheless, is very suggestive as far as it goes. I can here only summarise its main outcome.

The problem was, and always has been, how a substance which filled all space, without the least obstruction or resistance to the passage of matter through it—that is, which did not in the least interfere with the motions of the earth or any other heavenly body, and which therefore seemed to have the properties of a perfect non-viscous incompressible fluid or liquid—how such a liquid could, nevertheless, transmit transverse vibrations, such as can only be transmitted in the case of ordinary matter by solids with a certain amount of elastic rigidity; that is to say, by materials capable of elastic deformation and recovery. It was always known that no ordinary fluid could do this, it could only transmit vibrations at all if it were compressible; and the waves transmitted must be longitudinal waves, like those of sound. Newton it was who first investigated the transmission of sound, and showed that the speed was the square root of the ratio of pressure to density. That is all ancient history.

But now arose the question whether a fluid in vortex motion could transmit transverse waves. For vortices have many of the properties of a gyrostat; that is to say, properties naturally conferred upon them by rotation. And a gyrostat has a peculiar reaction to force, tending to move in a direction at right angles to the force, so that any impulse or disturbance might be expected to be transmitted in an unusual way. The result was to show that, given a medium full of minute vortices, circulating with a certain speed c, transverse waves akin to those of light, and therefore capable of polarisation, could be transmitted, and that they would travel, according to Lord Kelvin's calculation, with a speed $\frac{\sqrt{2}}{3}c$; that is, with about half the speed of circulation. FitzGerald's inquiry made the wave speed more nearly equal to c, but anyhow they were of the same order of magnitude.

Well, that possibility has not been followed up, nor that structure in the ether developed, because of many difficulties about stability and the like. Nowadays, however, a doubt about stability is not fatal, since something unexpected, like the quantum, may always come in to stabilise things. Bohr's orbits were not stable till the quantum arrived; and even now no one can fully explain the quantum, though, once admitted, it is perceived to have stabilising qualities, since it emphasises whole units, and declines to admit fractions; in other words, it rejects continuous changes and insists on discontinuity; jumps rather than slides, staircases rather than slopes.

But a more deep-rooted objection to any even quasi-dynamical theory is that all such attempts seemed superseded and rendered unnecessary by Clerk Maxwell, who showed finally and completely that the lateral or transverse disturbances associated with the propagation of light were electric in one direction, magnetic in the other, and not mechanical at all. Yes, that is undoubtedly true; but that is not the final word, it does not end the discussion. For what is an electric displacement in the ether, and what is a magnetic field? There always seemed something rotatory about magnetism, and, if so, there must be something which rotates. Electrification and magnetisation themselves want explaining: they are not functions of matter, they must be explained in terms of an etheric medium; and a gyrostatic or rotational medium is just what is wanted. According to Larmor's theory, a magnetic field is itself a kind of vortex, a bundle of filaments, with a flow along the lines of force, a flow which presumably constitutes the energy of the field.

If there is such a flow it must be excessively slow, for it has never been observed. I have specially looked for it.‡ But it is far too small. I have not given up all hope of observing it; but I have reason to think that an enormously strong field will be necessary before any trace of etheric motion becomes perceptible. If I were younger, I should like to press Dr. Kapitza into the service, and utilise his very striking methods of producing enormous currents and correspondingly strong magnetic fields, so that his coils have to be strengthened lest they fly asunder or explode under the magnetic stress. But although Dr. Kapitza can produce small local fields of enormous strength, even he cannot yet extend them over the length required to give a chance of detecting, by means of a beam of light, what I estimate to be a leisurely etheric crawl along the lines of magnetic force.

But why should it be so small? The answer is, Because the ether is a substance of tremendous density, utterly different from such estimates of density as were made by Lord Kelvin in the nineteenth century. For my estimate of ether density and its reasons reference can be made to the *Phil. Mag.* for April, 1907, page 488. Various modes of getting at it are therein indicated, and they, too, all lead to a result of the same order of magnitude, namely, about 10^{12} in c.g.s. units, assuming such units at least analogically applicable.

It may be asked, What does the density of ether mean? To that I can only reply—as usual—inertia per unit volume. And as to what "inertia" means, I can only say, Something very fundamental, perhaps the most fundamental thing in the physical universe, incapable of reduction to anything simpler. We know that the inertia of an electron is explicable in

‡ See *Phil. Mag.* for April, 1907, pp. 495 to end; also Preston's "Light," p. 316, for part of the apparatus.

a fashion, in terms of its electrostatic field, which exists in the ether all round it It seems to carry some ether with it when it moves, and its inertia is due to that, or rather to the magnetic field which is generated by the motion. This it is which causes its motion to persist, and which reacts against acceleration of any kind. But that is not a fundamental explanation of inertia. It only throws the mass of a moving speck upon the surrounding medium. The same must be said even if the electron is reduced to waves, and the momentum of waves is appealed to. Waves would not have any momentum unless the substance carrying them had inertia. I expect that it will be found that all inertia exists in the ether fundamentally. And if so, whether the estimate of 10^{12} is right or not, many physicists, including the high authority of J. J. Thomson, admit that etheric density must be incomparably greater than any known form of matter, even such exceptional matter as exists in the few known stars like the Companion of Sirius. For, after all, "matter" inevitably is a collection of discrete particles with interspaces between them, and, in itself, has no more substance than a thin cloud of dust or mist; it is like some granules of dirt distributed through an ocean of clear water.

If, for the sake of argument, you will grant me the high density of the continuous medium in which the particles of matter exist, and of which they are presumably composed, let us go back to the vortex structure of this ether, and the rate at which it transmits waves. Whatever we are ignorant about concerning the ether, we know this one thing definitely and accurately—the speed of radiation. It is a great speed, 3×10^{10}. Nothing in matter can approach it. It is only rendered possible by the extraordinary properties of the ether; but there is nothing haphazard about it or accidental, as would be the case with projectiles shot off. It is the speed, and the only speed, with which anything whatever is transmitted by the ether as soon as it gets free from contamination with matter. It is a definite and universal constant in really free space, and applies to every wave, however long and however short. And if that is not true, the error—at present quite unlikely and unsuspected by anybody—must be left to far-distant posterity to detect and substantiate.

The Building Trades Exhibition.

No. I.

The Building Trades Exhibition was opened on Friday of last week at Olympia, and is to close on the 26th inst. It is the twenty-first of its kind at Olympia, and it has attracted upwards of 370 separate exhibitors. It quite comes up to the standard reached by preceding Shows, and is representative of practically every department of the building trades. While, perhaps, there is no outstanding novelty to chronicle, numerous improvements have been introduced in last year's models and arrangements, a particularly noticeable move being the incorporation, in the design of machines and machine tools, of motors or other prime movers, so as to produce self-contained units and to dispense with belt drives. As far as can be judged by personal observation and by conversation with numerous exhibitors, the exhibition is a decided success. Not only are inquiries by prospective purchasers satisfactorily numerous, but, in many instances we hear of, substantial sales had already been effected by the beginning of this week.

As is usual at these Shows, there is a multiplicity of exhibits of materials and apparatus useful for the construction and equipment of buildings. Among these may be mentioned barrows, tip wagons, carts, conveyors, &c.; bathroom fittings; bricks, tiles, &c.; cements; dampcourse and waterproofing materials; decorative metalwork; doors and door furniture; earth and chemical closets; electrical heaters and fittings; entrance gates; fencing; floors, fire-resisting materials, &c.; glass and glazing; hardwoods and timber of all kinds; ladders; marbles and mosaics; metal casements and fittings; paints, paint brushes, enamels, varnishes, &c.; partitions, wood, metal, &c.; revolving doors and shutters; roofing materials; rubber floors and other goods; shop and window fittings; shuttering; steel construction and fittings; stone and stone preservatives; ventilators; and windows and fittings. With regard to the foregoing, which we cannot spare space to refer to in greater detail, it may be said that in practically every case the exhibits are of excellent character and particularly well displayed.

Of exhibits appealing more to the engineer than to the builder proper, there are numerous examples. Herbert Alexander and Co., Ltd., of Charmouth-street, Leeds, and 12, Broadway, Westminster, show a model of their "Hercules" Press for the manufacture of sand-lime bricks. H. and E. Lintott, of Horsham, have on view one of their "Vulcan" pugmills fitted with an elevator and crushing rolls. The elevator in this machine delivers the pug direct on to the table and thus does away with manual labour, at the same time further pugging the clay. The mill is designed for all classes of clay for the manufacture both of bricks and tiles, and its capacity is given as being from 800 to 1000 bricks per hour, according to the nature of the clay. The Pragos Engineering Company, Ltd., of 351, Brixton-road, London, S.W., exhibits an automatic proportioning, mixing and feeding machine, 12ft. long, which is fitted with a special cutter to deal with tough clay. This machine is intended to be essentially an automatic feeder which will ensure a regular adjustable feed of any material—whether it be lumpy or granular, dry or wet—to pan mills, drying drums, brick-making machines, &c. It is fitted with shutters to provide for easily adjustable proportioning and mixing, and is claimed to be suitable for dealing with all kinds of clay, with additions of grog, ashes, &c., or for proportioning sand, gravel or the like with lime, cement, &c.

No less than thirty-three exhibitors have exhibits dealing with concrete construction, machinery and plant. A.C.E. Machinery, Ltd.—the name of which was originally the Australia Concrete Machinery Company—of Porden-road, Brixton, London, S.W., shows, amongst other things, an up-to-date example of its "Tonkin" mixer for all kinds of materials, which has already been described in these columns, and a cube mixer of the rotary type in which the aggregate is thrown by a zig-zag movement from one cube face to another six times in each revolution of the drum. On the stand of Cowan, Hulbert, Ltd., of Abbey House, Westminster, are examples of its "Insley" concrete placing equipment, its "Rex" concrete mixers, its "Rooshors" self-locking adjustable shores, and its "Berg" concrete surfacing machines. On the stand of Goodwin, Barsby and Co., Ltd., of Leicester, we noticed, in addition to a 12in. by 6in. Acme stonebreaker, and a smaller machine for dealing with old bricks, concrete, soft stone, &c., an open drum concrete mixer fitted with a hoist and a smaller mixer on wheels for hand or belt power, to take in a batch of from 3 to 4 cubic feet. Mr. E. W. Hewett, of Bishops Waltham, has hand power concrete breeze and block making machines, which are said to be able to produce 700 blocks or 2500 bricks per day, and to compress without tamping. A moulding machine of a somewhat unsual form is to be seen on the stand of Lee and Fouracre, of Steventon, Berks. It is known as the "Lee Magnum," and is intended for the production of concrete or breeze bricks, slabs or blocks. The Liner Concrete Machinery Company, of Newcastle-upon-Tyne, has an extensive exhibit of concrete mixers, slab and block-making machines, flag moulds, &c. The "Liner" tilting drum machine has already been described by us, but the present model is of an improved type, and is made in sizes from 4/3 up to 8½ cubic feet of unmixed and 6 cubic feet of mixed concrete, and all sizes are fitted with "Lister" petrol engines. The particular sizes on view are the 4/3 and the 7/5 machines. Frederick Parker, Ltd., of Leicester, shows, in addition to stone breakers, its O.C. concrete mixer and its "Little Giant" mixer, which has a capacity of 4 cubic feet per batch, and only requires a 1½ H.P. petrol engine to operate it. Ransomes and Rapier, Ltd., of Ipswich and London, while they are showing nothing which is absolutely novel, have an effective exhibit of their "All-purposes," "Featherweight," and "Light Weight" mixers, in all of which detail improvements have recently been made. The "Light Weight" machine, which has a capacity of 7/5 cubic feet, and an average output of 40 to 50 cubic yards per eight-hour day, is to be seen in operation. Our readers are familiar with the construction of these machines. Several sizes of "Victoria" concrete mixers are on the stand of Stothert and Pitt, Ltd., of Bath. Two of them embody an innovation in that they are furnished with a hoisting winch. All of them are driven by "Lister" petrol engines, and all of them have an automatic water tank. As is always the case, Winget (1924), Ltd., of Grosvenor-gardens, Westminster, has an imposing stand on which there are many examples of its concrete-making and working machines, all of which, we were assured, if they were not entirely novel, at least embody new features. The Burn-Lancaster drum type open mixers of this firm are now made in twenty-six sizes, varying from a 5/3½ hand-operated machine, with an output of from 15 to 20 cubic yards per day, to a 14/10 machine, which has an elevating hopper and an automatic water tank, and which can maintain an output of from 120 to 150 cubic yards per day. Some of the machines shown are fitted with hoists. A typical example of these machines is shown in Fig. 1, which represents the 10/7 size. This sized machine can be equipped with a turntable, so that it can be readily changed from side to end loading and discharge, and can be steered in either direction, and it can also be fitted with an adjustable delivery chute for placing concrete within a radius of 8ft. With these additions, the machine is known as the "Roadmaker," and is said to be, perhaps, the most adaptable of all the Winget concrete-making machines. In addition to the foregoing and to other concrete and asphalt-mixing machines, this firm is also exhibiting numerous machines for making solid and hollow concrete blocks, and, among the latest productions, is the

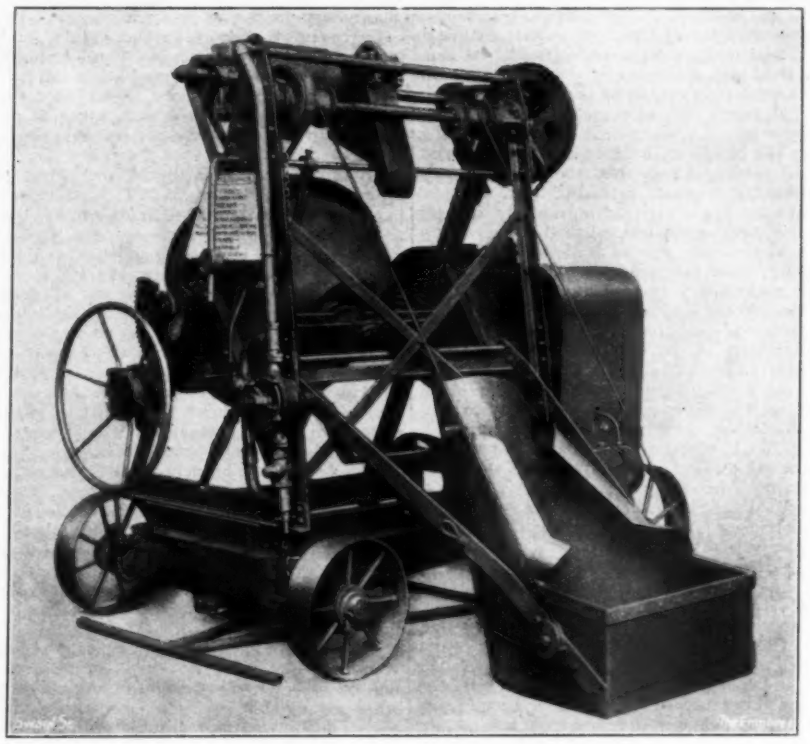


Fig. 1—10/7 Open-Drum Concrete Mixer—Winget

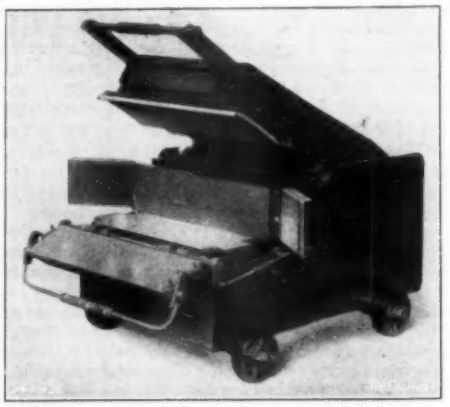


Fig. 2—Kerb and Channel Moulder—Winget

concrete kerb and channel-making machine which is illustrated in Fig. 2.

Several firms are showing machinery for the manufacture of paints. First of all, there are Marchant Brothers, Ltd., of Verney-road, Old Kent-road, London, S.E. They have a chain-driven three-roller grinding mill, which is fitted with 12in. diameter by 24in. long porphyry rollers. This machine is fitted with a special micrometer adjustment gear between the rollers. It is specially intended for grinding very fine paints and enamels. It is substantially built, and, as it is in operation, it can be observed that it is silent running. Other exhibits on this stand include a 6in. by 12in. triple chilled iron roller grinding mill, under-driven and mounted on a cast iron base for fixing on a bench or stand; a paint and enamel straining machine; a high-speed rotary disc grinding mill; and a rapid single-cone paint-mixing machine.

Sidney Smith and Blyth, Ltd., of Garratt-lane, Wandsworth, London, S.W., show a chilled iron single-roller mill fitted with reduction gearing, on a lateral motion cam. It is intended for grinding and finishing ready-mixed paints, enamels, inks, &c. This firm also has a two-roller and a three-roller mill, which are chain-driven and have roller bearings and may be fitted with either chilled iron or granite rolls, and be with or without lateral motion. There are also combined plants, comprising a 30in. by 30in. twin paste mixer mounted over a tandem two-roller mill for pastes, semi-pastes, and liquid; edge runners, whirlpool mixers, &c.

Torrance and Sons, Ltd., of Bitton, near Bristol, have on view a special new design of high-speed roller mill for the superfine grinding of paints, &c., and also a 30in. by 15in. S/Q triple-roller mill fitted with porphyry rolls, micrometer adjustments and worm reducing gear. It is driven by an electric motor. There are, too, a "Full" Micro-Twin roller refining mill for the superfine grinding and cleansing of all kinds of enamels and paints, a "Middle" Micro-Twin and a "Baby" Micro-Twin machine, as well as a "Vortex" mixer for the rapid dilution of paints, enamels, &c., and a horizontal mixer for cellulose and for the mixing and dilution of paints, enamels, &c.

Among the exhibits of most interest to mechanical engineers are those devoted to wood working machinery, of which there are a dozen or so, all of which are worthy of attention. Wadkin and Co., of Leicester, have a stand full of interesting tools. Three of them are illustrated in Figs. 3, 4 and 5. Fig. 3 shows an 18in. canting spindle dimension saw. For this machine it is claimed that it will rip, cross cut or mitre equally well, in any kind of wood, and that the cut is made so smoothly and accurately that the joint can be glued up straight from the machine. In machines of this type it is usually the tables which tilt, but in the present machine the saw is mounted direct on the motor shaft, which can be canted to any angle up to 45 deg., the table always remaining horizontal. The makers claim that this feature is a great improvement over the canting table, that it makes the machine safer and simpler for working, and that, in practice, it enables production to be speeded up by at least 30 per cent. The machine embodies the following features in addition to those just mentioned:—(*a*) The spindle is carried in ball and roller bearings; (*b*) the saw has vertical adjustment for convenience in rebating, trenching, grooving, &c.; (*c*) the front portion of the table slides on ball bearings, and is locked when desired in the central position by a spring plunger; (*d*) the front of the table is made to draw back 4in. from the saw; (*e*) the table is provided with a scale graduated in degrees for the quick setting of fences; (*f*) there is a special hood below the table for protecting the operator and for throwing the sawdust clear of the machine; (*g*) the saw guard above the table is raised and lowered by screw motion, so that it is prevented from falling accidentally on the saw; (*h*) the riving knife is fitted to the saw frame and is raised and lowered with the saw; and (*i*) both back and front table are grooved for mitre fences. The machine has a maximum depth of cut of 4in. It will cross-cut 4in. deep up to a width of 30in. and 1in. deep up to a width of 36in. It will cut off, using the standard stops on the fences, up to a length of 36in., and will admit between saw and ripping fences with a saw guard 22in. Without the saw guard it will admit material up to 24in. between the saw and the ripping fence.

Another interesting saw being shown by this firm is shown in Fig. 4. It is an automatic motor-driven cross-cut saw which will cut off 20in. wide and 4in. deep. It is claimed for this machine that it is specially suitable for close accurate work, and that, with it, many operations which previously necessitated cutting oversize and then jointing to the final close dimensions can be completed outright. In it the timber being cut remains stationary; it is the saw itself that moves. The machine is entirely automatic in its action. The operator has merely to place the timber in position on the table and to press a foot lever at the front of the machine. The saw then moves forward through the cut. The saw carriage, when the cut is completed, is quickly and automatically returned to its starting position. The timber is then again placed in position for the next cut and the operations are repeated. A third machine of novel design made by Messrs. Wadkin and Co. is shown in Fig. 5. It is a motor cross-cutting and trenching machine. This machine, it is claimed, embodies many new labour-saving features, and will perform many important operations, which are not possible with the ordinary type of swing cross-cut saw. It is made in three forms:—(*a*) For plain straight cross cutting; (*b*) for angular sawing, trenching and grooving; and (*c*) for mitre cutting, angular sawing, and trenching and grooving. In the last case the spindle can cant, and swivelling and rising and falling motions can be imparted to the spindle. Among the special features claimed for this tool are that the saw operates in a straight line and not in an arc as in the swing saw, that the motor is mounted direct on the saw spindle, and that the saw spindle can be canted from the horizontal to the vertical position, all the important angles being registered. The standard diameter of the saw in this machine is 18in. It will cut off 20in. wide, 4½in. deep, 21½in. wide, 4in. deep, 23in. wide, 3in. deep, 24in. wide, 2in. deep, and 25in. wide, 1in. deep. It will also cut off 20in. wide and 4½in. deep when the saw is canted to 30 deg., will groove up to 2½in. wide and 1½in. deep in material 18in. wide, and up to 2½in. wide, 1½in. deep in material 12in. wide when the carriage is pivoted to 45 deg. The maximum rise and fall of the saw is 9½in. A motor of only 5 H.P. is required to drive the machine.

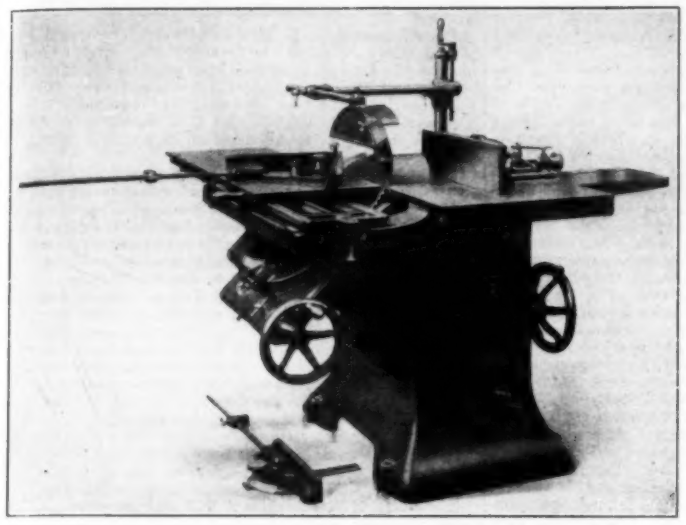


FIG. 3—CANTING-SPINDLE DIMENSION SAW BENCH—WADKIN

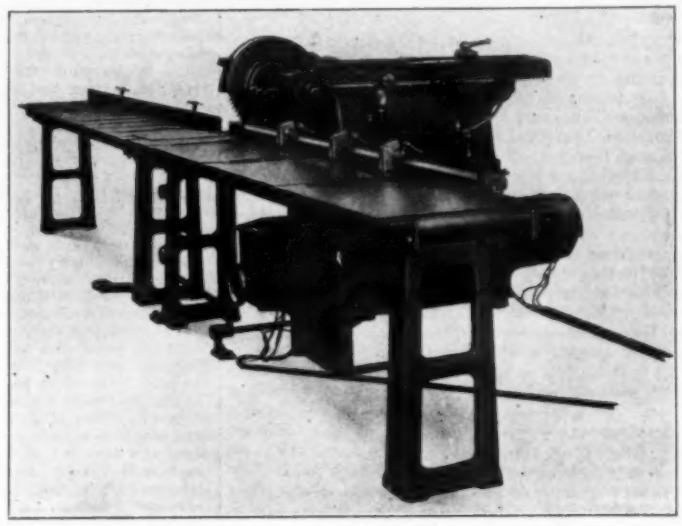


FIG. 4—MOTOR-DRIVEN AUTOMATIC CROSS-CUT SAW—WADKIN

Other tools shown by this firm were a band saw, a combined surfacing, a thicknessing machine, and various mortising and tenoning machines.

We shall refer to other wood-working tools in a future issue.

Lifts, cranes, hoists or conveyors are shown by some eight firms, that is, in addition to those makers which are showing elevating machinery combined with other things. Perhaps first mention should be made of Waygood-Otis, Ltd., which is working a passenger lift from the floor of the Main Hall to the gallery level. The lift, which is operated electrically, is furnished with the firm's patented micro-drive self-levelling device, which is claimed automatically to ensure level stopping at the floors in either direction, irrespective of the load in the car. The lift is so arranged that it can be operated by car switch or on the full automatic push-button system. Other exhibits of this firm include models of an automatic

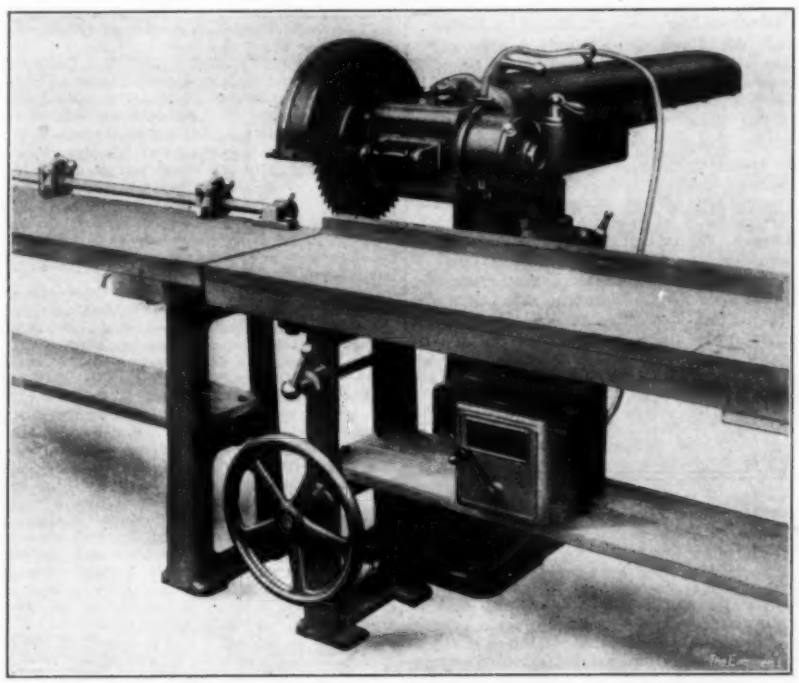


FIG. 5—MOTOR-DRIVEN CROSS-CUTTING AND TRENCHING MACHINE—WADKIN

electric passenger lift, and of a double-worm tandem machine for operating escalators, as supplied to the Underground Electric Railways.

Marryat and Scott, Ltd., of 40–57A, Hatton-garden, London, are giving demonstrations of what they term their Universal Utility Lift, the demonstration taking the form of installation "from the crate to completion." This machine, which is exhibited for the first time, is an electric push-button lift designed to raise a load of 40 lb. at a speed of 80ft. per minute. It is described by its makers as being entirely new in conception, design and construction, and as being suitable for connection on any alternating or direct-current supply, and complete in every respect, including all apparatus, &c. for erection in a self-supporting tower by unskilled labour. This firm is also giving a display of the Marryat-Scott lift, which is claimed to afford complete safety to passengers and to conform with the requirements of the Home Office, the Board of Trade, the Institution of Electrical Engineers, and the Fire Insurance Companies.

Medways (Safety Lift) Company, Ltd., of Dartford, and 1 and 2, Silex-street, Blackfriars, London, S.E., is showing its latest pattern worm-geared electric lift equipment, which is fitted with a "V" sheave drive, and also with an electrically-operated control panel and rheostat. The gear and controller are connected up to an operating switch, as in car-switch lifts. On this stand, too, there are an electric service lift designed for private houses and a hand-operated service lift fitted with self-sustaining gear. There is also being demonstrated this firm's automatically operated opening and closing device for lift doors.

What is known as their "Turn Lift" is exhibited under working conditions by Wm. Wadsworth, of Bolton. This lift has been designed mainly with a view to garage work. It is claimed that, with it, whatever may be the position of the car there is no twisting, as the lift will deliver at any point of a circle on any number of floors; that is to say, that the lift acts not only as an ordinary lift, but as a turntable on each floor as well. Another exhibit of this firm is a new two-speed lift for alternating current. With the arrangement it has adopted the firm claims to be able to supply lifts for alternating current which are equal in every respect to those operated by direct current. Any speed can, it is stated, be obtained. Other claims made for the system are that it uses less current than does any other system, while the control is as simple as with an ordinary lift.

Of recent years various refrigerators for use in the household have been put on the market. It is perhaps difficult to understand why such machines, if so they may be called, should find a place in a building exhibition, but there some of them are, and perhaps the explanation is that, after all, what is the use of a building without the equipment inside it?

There is first of all the electrical refrigerator shown by Easiwork, Ltd., of 303, Oxford-street, London, W. Then there is the refrigerator exhibited by Electrolux, Ltd., of 153-155, Regent-street, London, W. This machine has not a single mechanical moving part to call for attention, and it works entirely without noise or vibration, yet it is claimed for it that it performs in the home the full duty of the most elaborate mechanical ice plant for the preservation of foodstuffs and beverages, and for the making of ice for the table and the sick-room.

Another household refrigerating machine is exhibited by Frigidaire, Ltd. (Incorporated in Canada), of Chapter-street, Westminster, S.W. This firm is showing several household cabinets and also a battery of sixteen Frigidaire cooling coils operated from one 1 H.P. compressor, so as to demonstrate the principles of multi-refrigeration as applied to a block of flats. It is stated that, under suitable conditions, one 1 H.P. compressor will operate as many as twenty small Frigidaire cabinets. A claim made for the Frigidaire electric refrigerators is that they are entirely automatic, being self-starting, self-stopping and self-oiling.

(To be continued.)

The Variable Pitch Airscrew.

A paper read before the Royal Aeronautical Society at the Royal Society of Arts, on Thursday, April 12th, drew a large attendance. It was presented by Dr. H. S. Hele-Shaw and T. E. Beacham, and the subject was one which has been a matter of research and controversy in aeronautical circles, viz., the variable pitch airscrew. It has long been recognised that a fixed airscrew cannot give the best results under all flying conditions, and that its design, therefore, has to be a compromise. The subject of variable airscrews has necessarily exercised the minds of aeronautical engineers ever since the underlying principles were clearly understood and the records of the Patent Office show many attempts to evolve mechanisms to this end. These include devices to vary the diameter and surface of the blades as well as to alter their pitch, but the paper by Dr. Hele-Shaw and Mr. Beacham only dealt with the variation of the pitch, as it is realised that the mechanical difficulties in the way of varying any of the other physical proportions are undoubtedly very great. At the same time it is recognised by the authors in the present case that by the variation of the pitch alone only part of the possible theoretical increase in efficiency can be realised.

For aircraft operating with engines not fitted with superchargers, the chief advantage of the variable pitch airscrew would appear to be a greater efficiency at climbing speeds, as by reducing the pitch the drop in engine revolutions and consequent loss of power which occurs with a fixed pitch propeller is avoided. The variable pitch airscrew also prevents the loss of engine power resulting from the fall in speed which occurs at high altitudes. It is the conditions connected in the supercharged engine, however, that have led the authors to investigate this problem, because with such engines the possibility of varying the pitch to suit different altitudes becomes a matter of prime importance as the power absorbed by a fixed pitch propeller is approximately proportional to the air density, whereas the supercharged engine should maintain something approaching constant horse-power up to a predetermined height. With a normal fixed propeller, therefore, it would be impossible to make use of the full power of the supercharged engine at any great height without excessive revolutions. The difficiulty can be overcome by using a fixed propeller, of greater pitch, but only at a great sacrifice of efficiency when flying at lower altitudes. These, then, were the conditions which had to be faced in tackling this problem.

The mechanisms which have been put forward of late years for varying the pitch of an airscrew were classified in the paper under the three heads of manually-operated gears, power-operated gears where the pitch is controlled by hand, and power-operated gears in which a governor regulates the pitch. The authors believe that the methods falling under the third class present the ideal solution of the problem. In these methods the governor weight or weights may act directly through a spring to control the pitch of the blades or it may act through some form of servo-motor. Both electric and hydraulic methods have been suggested for providing the necessary power, so that a mere pilot governor is sufficient to vary the pitch of the blades. The Hele-Shaw-Beacham system is hydraulic. Following the first appreciation of their invention by the technical staff of the Air Ministry, the authors were fortunate to secure the co-operation of the Gloster Aircraft Company in its further development, and that company has been occupied for the last eighteen months in developing this hydraulic variable airscrew. A large number of designs for many of the chief types of aircraft engine have been prepared at Cheltenham by Mr. H. L. Milner, working under the direction of the chief engineer and designer of the Gloster Works, Mr. H. P. Folland. The first design to be actually carried into practical effect is that for the "Jupiter" engine, and the authors acknowledge their indebtedness to the Gloster Company, which is the sole licencee and manufacturer of the new airscrew, for the manner in which the development of the invention has been taken in hand.

The pitch of the blades in the Gloster Hele-Shaw-Beacham variable pitch airscrew is varied by means of a double-acting hydraulic piston operated by the oil pressure from a variable stroke pump driven by the engine. The stroke of the pump is in turn controlled by a governor, also driven by the engine, so that whatever the air conditions may be, the pitch of the airscrew sets itself so as to keep the engine running at a constant predetermined speed. Although the apparatus is automatic, the speed at which the governor operates can be altered by the pilot within certain limits by means of a small control lever. In other words, the pilot has it within his power to speed up the engine and obtain extra power in an emergency, and also, on the other hand, to reduce his engine speed so that he may cruise at full throttle, this, of course, being the condition for minimum petrol consumption per B.H.P. developed by the engine. The pilot control lever alters the force on the governor spring and consequently adjusts the speed at which the governor operates.

The principle of operation of the variable pitch air screw is identical with that of the hydraulic steering gear with the addition that the control is made automatic. An important matter insisted upon by the Air Ministry is provision for any possible failure of the hydraulic system, for instance, if in a war machine the pipes were shot away. It is claimed that this condition is satisfactorily met in the particular airscrew referred to, together with the other two vital conditions of light weight and reliability. It may be added that one of these airscrews has been thirty hours in flight at Farnborough—where it is being tested by the Air Ministry officials—without any suggestion of breakdown.

In the discussion on the paper, the chairman—Colonel the Master of Sempill—said that that particular airscrew had so far proved the most successful of the several variable pitch airscrews which had been tested.

Mr. Lynam, who is in charge of the Airscrew Sections of the Royal Aircraft Establishment, said that a great deal of the gloss was taken off the variable pitch airscrew proposition by the weight. In many cases that annulled the advantages to be gained, and despite the success of the Gloster Hele-Shaw-Beacham airscrew, he was not yet convinced that a very strong case could be made out for the variable pitch airscrew, in general, for heavier-than-air craft. A good case, however, could be presented for this type of airscrew on the airship. It appeared that the variable pitch airscrew stood the best chance on geared engines when screws of large pitch and diameter ratio and large surface were used. Mr. Lynam's remarks may be summarised by saying that unless by using a variable pitch airscrew—and taking the weight of the airscrew into account—we can obtain more power from the engine, and unless the additional power is gained at the rate of, say, 1 H.P. for 2 lb. weight, we should do better by putting that weight into the engine and using a fixed screw propeller. One of the things necessary, he said, was a metal for the blades very much lighter than was available to-day. The Gloster airscrew for the "Jupiter" engine weighed about 180 lb. as against 100 lb. for a fixed airscrew of the same size with substantially the same blades—solid duralumin. An increase of 80 per cent. in the weight was caused by the introduction of the mechanism for varying the pitch of the blades. He did not believe any form of solid construction would ever give light enough blades; hollow construction would have to be adopted, at any rate, for such large engines as the "Jupiter." Another means for reducing weight was to depart from the practice of attaching the blade rigidly to the centre. If the blade was hinged to the centre it became very much lighter because it was relieved of some of the bending, and the centre became appreciably lighter for the same reason. The bending forces, which were due to thrust on the blade disappeared, a very much smaller journal bearing was called for, and also, by reason of the lighter blade, a smaller thrust bearing. Given these light, hollow-hinged blades, he believed that it would be possible to produce an airscrew for the "Jupiter" engine having a weight of 80 lb. or 90 lb. at the outside, and even 50 lb. to 60 lb. Mr. Lynam did not speak very favourably of an automatic apparatus because of the mechanism involved, except perhaps in single-seater fighting scouts. For large aeroplanes and seaplanes carrying heavy loads he favoured the simpler manually-operated gear. Hydraulic mechanism had been proved very reliable, although on much larger apparatus than those which would be used on airscrews. As to the tests at Farnborough of the particular airscrew described in the paper, no official report had yet been forwarded to the Admiralty.

Mr. Lynam's contribution to the discussion must be regarded as the most important having regard to his position in the matter, but a long discussion followed his remarks.

Wing-Commander T. R. Cave-Browne-Cave said that the author's airscrew represented an extraordinarily beautiful and simple solution of a very complicated problem, and it had the very remarkable characteristic that it appeared to be all that the mechanic required. It was automatically controllable, and if it failed, it would go back to the one and only position in which it would be safe.

Flight-Lieutenant Capon said that it was very difficult to be quite sure what improvement would be effected by the use of a variable pitch airscrew. The questions of the behaviour of such a mechanism at full throttle, when throttled, and on supercharging, were all separate problems. His own experience and experiments suggested that the advantage of the variable pitch airscrew was more than counterbalanced by the extra weight at a pitch diameter ratio of 0·6, but there was the possibility of using such a device with advantage at a pitch diameter ratio of 0·9 or thereabouts. It did not appear, however, that a case could be made out for the variable pitch airscrew in the larger machines and especially in multi-engined machines, because of the extra weight of the several mechanisms which would have to be carried.

Wing-Commander Hynes expressed the view that the case for the variable pitch airscrew was very difficult to support for reasons of increased cost, increased maintenance charges, and increased chances of breakdown.

Mr. H. L. Milner suggested that the criticisms on the score of weight were not quite fair, because that was the first model of its kind to be produced. As a matter of fact, designs had now been produced which indicated that the full equipment of the variable pitch gear in connection with the Condor engine could be provided with an increase in weight of only 50 lb., which was only 0·07 lb. per H.P.

Mr. Bramson suggested that there was a wave of undue pessimism in most of the speeches, based on the supposition that the results hitherto obtained with the variable pitch airscrew were the best that would ever be obtained. It seemed essential, when a supercharger was fitted, to have a variable pitch airscrew, otherwise all the advantages of the supercharger, at high altitudes, would be lost.

Captain Boothby said that in 1912 he was in command of an airship fitted with variable pitch propellers, but he asked that they should be taken off because they were so thin—about the thickness of ordinary brown paper—that he did not regard them as safe.

Several other speakers took part in the discussion, and expressed views which indicated distinct differences of opinion as to the advantages and disadvantages of the variable airscrew whilst complimenting the authors of the Gloster Hele-Shaw Beacham design.

The authors, in their replies, commented on the fact that most of the criticism has centred on the question of weight, and pointed out that later models would necessarily be much lighter than the original. Dr. Hele-Shaw made a characteristically racy speech, in which he recalled that the problem had previously been attacked by very acute minds—many of them at Farnborough—and he, too, forecasted that the weight of the device would be materially reduced in the future. He welcomed the criticisms, and did not expect to be patted on the back for having done what Farnborough had not yet done, viz., produce an airscrew which did all that was required of it. The paper had not been written to show what a wonderful thing had been invented, but to have the weak points criticised.

WATER FOR PORT ELIZABETH.

Owing to the prolonged drought, the position at Port Elizabeth with regard to water supply recently became somewhat serious, though rain subsequently fell and relieved the situation. In order to try and avoid a repetition of the shortage, the City Council has accepted the report and recommendations submitted by Messrs. R. W. Newman, M. Inst. C.E., and D. P. Howells, M. Inst. C.E., regarding augmenting the city's water storage. At present there are three reservoirs with capacities of 29, 124 and 184 million gallons. The present capacity of the pipe lines is 2½ million gallons per day, but a new line from Bulk River to the Linton service reservoir is now approaching completion, and has a capacity of 2 million gallons. The report recommends work at all three storage sites. At Van Staadens an entirely new dam, with a 60ft. wall, 375ft. long at the crest, is proposed, below the old dam. New filters of the pressure type will be required. This section is estimated to cost £30,000, and will give an additional 70 million gallons of storage capacity.

At Bulk River it is proposed to raise the existing wall 10ft., carrying the new work up from the foundation level on the downstream side of the wall and thoroughly sealing the foundations by cementation. The cost is given as £35,000, and this work will provide an extra 200 million gallons capacity. At Sand River another 200 million gallons of water storage will be secured by raising the wall an extra 15ft., at a cost of £36,000. It is estimated that the work at each site will occupy about eighteen months. In the meantime, temporary measures are suggested for the raising of the top water levels at Van Staadens and Sand River reservoirs by about 2ft. in each case. In addition to adopting these schemes, immediate steps are to be taken to investigate new sources of supply. The total storage capacity on completion of the works decided upon will be 716 million gallons.

Railway Matters.

DURING the first six weeks of the present year the London, Midland and Scottish Railway ran 1·1 per cent. more train miles than in the corresponding period of 1927, but 10·9 per cent. less engine hours were required, and so the company saved £56,000 in locomotive running wages.

THE long-distance engine workings on the Great Western between Paddington and Plymouth, 226 miles, are well known, but there are others on that line which, although slightly shorter, are worthy of note. They are:—Paddington and Carmarthen, 220 miles; Newton Abbot and Shrewsbury, 215 miles; Birmingham and Carmarthen, 195 miles; and Banbury and Swansea, 163 miles.

THE retirement, at the end of the present year, is announced of Sir Francis Dunnell, Bart., the chief legal adviser to the London and North-Eastern Railway. At the time the war broke out Sir Francis was the solicitor to the North-Eastern Railway, and was loaned to the Admiralty in 1917. When the Ministry of Transport was formed in 1919 he became its secretary and solicitor, but retired therefrom at the end of 1921. When the London and North-Eastern was constituted as from January 1st, 1923, he became its legal adviser.

FROM the monthly article contributed by the general manager to the April issue of the *Great Western Railway Magazine*, it appears that, during the four weeks ended on February 18th last, the company ran 121,106 trains, of which the average late arrival at destination was only 1·7 minutes. Of the total, 43,191 were local trains, with an average of 2·1 minutes, and 66,169 were branch trains, with an average of 1·2 minutes. The London and West of England averaged 3·3 minutes, and the South Wales 3·1 minutes. The worst time keepers were the trains between London and the North and the cross-country trains, in which lattor other companies were concerned. Those two classes averaged 5·4 minutes and 5·3 minutes late respectively.

THE Canadian Government has presented estimates to its House of Commons asking for the appropriation of approximately 25,000,000 dollars for important additions and betterments to the Canadian National Railway system. Of the total, 9,000,000 dollars are required for the purchase of 160,000 tons of new rails, of a heavy type, which will be laid over a total of 1065 track miles, on the Atlantic, Central and Western regions, also on the Grand Trunk Western lines. The railway management states that, to produce operating economies, heavy freight locomotives with large tonnage trains are being continually adopted, and the weight of rails is being steadily increased to meet that condition. Rock ballast will be extended over additional mileage. In the installation of steel bridges and culverts, 2,225,000 dollars will be expended. On the provision of additional passenger freight, Diesel-electric equipment, &c., and in the installation of new devices to locomotives and cars it is proposed to expend 5,800,000 dollars. The most important of the improvements and additions to shops and engine-houses will be the new locomotive and machine shop at Point St. Charles Montreal, for which 1,000,000 dollars is provided, in addition to 450,000 dollars for a new power plant. Improvements in the facilities for passengers are planned at various points, including Hamilton, Ontario, and St. John, New Brunswick.

ACCORDING to the Board of Trade returns the value of the railway material exported during the first two months of the railway material exported during the first two months of the present year was as follows, the corresponding figures for 1927 and 1926 being added in brackets:—Locomotives, £409,859 (£142,309, £851,642); rails, £702,487 (£188,879, £403,486); carriages, £801,284 (£382,000, £272,538); wagons, £693,847 (£324,491, £762,632); wheels and axles, £204,976 (£58,055, £88,707); tires and axles, £113,740 (£51,523, £54,403); chairs and metal sleepers, £151,479 (£40,839, £121,308); miscellaneous permanent way, £188,441 (£182,043, £174,666); total permanent way, £1,361,123 (£521,339, £842,570). The weight of the rails shipped was 79,550 tons (16,034 tons, 47,031 tons); and of the chairs and metal sleepers, 15,097 tons (4666 tons, 12,422 tons). During February alone locomotives were sent overseas to the value of £237,474, which included:—Other countries than the Argentine in South America, £106,036; India, £55,555; Straits Settlements, £11,810; the Argentine, £6556; South Africa, £6480; Ceylon, £4374. The rails shipped in February were of the value of £319,232, and included:—The Argentine, £121,813; India, £72,277; Australia, £62,229; Straits Settlements, £16,121; Ceylon, £11,665; West Africa, £4621; New Zealand, £3118; and Chile, £3006.

THERE were three train accidents last year in which passengers lost their lives, the first being at Hull on February 14th and the second on August 24th at Sevenoaks. The third was on December 7th at Peterborough, North, on the London and North-Eastern Railway, as to which the report by Lieut.-Colonel Mount has recently been issued. The accident occurred during a fog, when visibility was variously estimated as from 15 to 30 yards. A London, Midland and Scottish passenger train had just started on its way to Peterborough, East, station, when it was run into by a London and North-Eastern excursion. A passenger in the former train was seriously injured and died two days later. The driver of the excursion train admitted that he saw the "on" position of the distant signal at the box next in the rear, but thought he caught sight of the stop signal there in the "clear" position. He admitted, however, that the distant arm, under the stop arm, for the next box was "on," and therefore he ought to have been prepared to pull up at the Peterborough North home signal. That he failed to do, and so, having ignored two distants and two stop signals, his engine struck the passenger train when still running at about 10 miles per hour. As Colonel Mount remarks, "It is fortunately an exceptional, though none the less serious, case of incautious driving under conditions of very restricted visibility." In his conclusions, that officer points out that the only positive means of preventing a repetition of such an accident would be by installing some system of automatic train control. A detonator-placing lever in Peterborough North box is also recommended.

Notes and Memoranda.

THE requirements of the American steam railways for wood sleepers amount to some 110,000,000 pieces a year; but it is said that there is no immediate prospect of the supply of appropriate timber being exhausted.

A GERMAN firm at Duisburg is offering to build steel dwelling-houses measuring 8 m. by 8 m. up to 8 m. by 12 m. in plan area, at prices ranging from 6900 marks up to 9780 marks. The output of the works is put at 1500 houses a year.

IN the course of a lecture given at the Building Exhibition, Dr. R. E. Stradling said that in the majority of our buildings the construction was much too heavy, when judged from strength requirements alone, and this extra weight had become traditional because of the other factors required for construction. The requirements of weathering resistance, heat insulation, and the like made demands often very much more serious than that demanded by strength.

A RATHER novel method of providing material for building up the dykes of rivers is described in a short note in *Engineering and News-Record*. The flow of the river, or rather canal, was diverted systematically into the borrow pits which had been made originally in the formation of the banks. These pits were filled up with silt from the main stream to the extent of about a foot a month and the material was subsequently dredged out to provide topping for the dykes.

GREY iron castings used by the Ford Motor Company, Fordson, Mich., for several of the smaller parts of its motor cars are heat treated in continuous furnaces before machining to eliminate hard spots, produce a fine grain structure, make the metal softer and easier to machine, and consequently speed up production in machine work on the castings. Some of the light castings, particularly carburetter castings, require small drill holes. After the annealing operation drilling is done more rapidly and there is less breakage of drills.

IN connection with the investigation of atmospheres in mines the Pittsburgh Experimental Station has carried out a number of experiments during the past three years and has developed an instrument for recording extremely minute concentrations of carbon monoxide in air. Work on the improvement of this apparatus and the extension of its usefulness is still in progress. Catalysts have been suggested as means of eliminating the carbon monoxide hazard from motor car exhaust gases. Certain existing catalytic materials are being tested for efficiency in this capacity.

ACCORDING to the *Chemical Trade Journal*, experiments with Red Deer Valley lignite by the Lignite Products Corporation of America at its Midland plant, have been successful. The experimental plant (Newbury system) utilises electricity to heat the coal in vacuum. The raw coal enters the retort and passes through ten tables, being heated gradually by electricity to a temperature of 1150 deg. Cent. at the bottom table. The coal does not burn, being in vacuum all the time. After being cooled by water it is brought out at the bottom as char. The gases are drawn off by a vacuum pump, cooled, and by-products extracted.

A MAINTENANCE principle is emphasised in the following remarks made by the Board of Trade Engineer Surveyor-in-Chief in connection with the blowing up of a steam-jacketed boiling pan in a chemical works. He says:—"The fact that this boiling pan was allowed to stand idle for long periods should have been sufficient reason for a careful examination of the pan and the fittings in connection with it on each occasion it was again brought into use. The reducing valve was inoperative through neglect, but a reducing valve in the steam supply is not of itself sufficient safeguard against over-pressure, as demonstrated in this explosion, and a relief valve should also be fitted in all cases where the boiler pressure is in excess of the working pressure for which the vessel concerned was designed."

SOME severe strictures on the owners are made in a recent report on the explosion of a steam wagon boiler in Blackburn. The Commissioners say that in their view the prime cause of the explosion was almost certainly the weakness of material through deterioration caused by corrosion, and they cannot admit the contention that such deterioration was unascertainable with ordinary care and intelligent supervision. It was even urged that no reliable evidence of this cause of the explosion had been adduced. But they are clearly of opinion that the gradual waste caused by grooving at the bottom flange of the fire-box should have been known to the owner and his foreman, and dealt with as a serious defect rendering necessary the dropping and the internal inspection of the fire-box. The proper remedies should have been at once applied, and the Commissioners have no doubt that this course would have been adopted had the knowledge of the defect been taken more seriously. A more thorough inspection would have yielded the proper result.

BY a Ministerial Order issued on March 10th, 1928, the Chinese Ministry of Industries promulgated a set of detailed regulations governing the enforcement of the Patent Law, which contain the following important points:—The application for a patent right and the explanatory note attached thereto should be written in the national (Chinese) language and any foreign technical term therein should be accompanied by a translation in Chinese. In the explanatory note should be stated:—(1) The name of the invention or newly discovered improved method of manufacture; (2) its purpose and scope; (3) its manufacturing processes and method of operation, if it is a mechanical instrument; (4) the name or names and place of production of the raw materials used in its manufacture and manufacturing processes, if it is a chemical product; and (5) the scope and time-limit of the patent rights applied for. In case of the object for which a patent right is applied being a mechanical instrument, the applicant should accompany his application by the invented machine or a model, together with detailed illustrations; and in case of the object being a chemical product, discovered or improved, samples should also accompany the application.

Miscellanea.

A LARGE vinegar factory is to be put up in Toronto by Crosse and Blackwell. The machinery is being imported from England.

THE Winnipeg Electric Company has contracted to supply 30,000 horse-power at half a cent per kilowatt-hour or 13·8 dollars per horse-power per annum.

IT is estimated that the waterworks improvement scheme for Decca, India, will cost 480,000 rupees, and that the annual cost for maintenance will be 4000 rupees.

IT is proposed to control the head waters of the Clarence River, New South Wales, for the purposes of flood protection and power production, at a cost of about three-quarters of a million sterling.

THE Meteorological Service of Canada has established a weather bureau at St. Hubert Aerodrome, near Montreal, under the direction of the Naval Service, in connection with the proposed Transatlantic air service.

AN extensive scheme of sinking tube wells for water supply has been inaugurated in the Sadar and Serampore districts of India. Already 476 wells have been sunk, and arrangements are made for boring 150 more wells.

THE tank steamer "San Jeronimo," of 12,000 tons, has been bought from the Eagle Oil and Transport Company by a whaling company for conversion into a depôt ship. She will work in the southern seas in company with three catchers.

THE Canadian Forest Products, Ltd., backed by the International Harvester interests of Chicago, will be allowed to erect a 200ft. dam on the Nimpkish and to flood areas around Nimpkish Lake in the development of their power scheme.

DURING 1927 the port of Beira, Portuguese East Africa, handled 820,624 tons of cargo, an increase of about 27 per cent. over the best previous figures—1925—and 60 per cent. above the cargo movement of 1923. Last year's traffic was almost three times that of 1913.

A SHIPBUILDING record is claimed by the Smiths' Dock Company, Ltd., Middlesbrough, with the "Conisclife Hall," 1900 tons, built for the Hall Corporation of Canada, for work on the Great Lakes. Her trial run will take place to-morrow, exactly eight weeks from the laying of the keel.

A VESSEL which has recently been put in service between Penang and Singapore completes the voyage more quickly, according to *Indian Engineering*, than is possible by the train. She is of 2200 tons, and was built at Barrow-in-Furness. Her machinery comprises Parsons turbines of 5800 horse-power, and she has a speed of 18 knots.

IN September next an important meeting of the International Illumination Commission, which was formed in 1900, and includes both the gas and electrical interests, is to be held in America. Mr. Buckley, of the National Physical Laboratory, Teddington, who is the secretary of the British National Illumination Committee, will gladly furnish full particulars.

ACCORDING to *The Times*, the engineering department of the General Post Office is making experiments with the idea of sending a telegram as a picture, so that it shall reach the person to whom it is addressed as a facsimile of the handwriting of the sender. Should this be successful another form of charge may be substituted for the present system of payment based on the number of words.

BOTH in output for February and in cumulative totals for the first two months of the current year, the primary iron and steel industry of Canada shows a sweeping advance over the totals of a year ago. Pig iron production in February was 28 per cent. above the corresponding month a year ago, while for the two months the increase was 26 per cent. The gains in steel output were much larger, 78 per cent. in February and 61 per cent. for the two months as compared with the corresponding periods of 1927.

THE Mechanical Warfare Board, which was appointed to advise on technical problems connected with mechanised transport of all types for Army requirements, and to secure liaison with the mechanical engineering industry, has formed a technical sub-committee, to which Colonel A. E. Davidson, M.I. Mech. E., R.E., Lieut-Colonel N. Hudson, M.I. Mech. E., A.M.I.E.E., and Major R. K. Hubbard, A.M.I. Mech. E., have been appointed. The duties of the new sub-committee will be to carry out the detail work arising out of the activities of the main board.

IT is reported by the National Federation of Iron and Steel Manufacturers that the number of furnaces in blast at the end of March was 150, a net increase of 2 since the beginning of the month, 4 furnaces having gone into blast and 2 ceased operations. Production of pig iron in March amounted to 592,600 tons, compared with 550,800 tons in February and 671,800 tons in March, 1927. The production includes 194,900 tons of hematite, 202,300 tons of basic, 151,800 tons of foundry, and 24,900 tons of forge pig iron. Production of steel ingots and castings in March amounted to 793,300 tons, compared with 764,400 tons in February and 949,600 tons in March, 1927.

A MESSAGE from Berlin states that on April 12th trials were carried out at Ruesselsheim on the Main, with a driverless motor car propelled on the Rocket system, and a speed of 430 miles per hour was attained for a few seconds. Herr Opel claims that there is practically no limit to the speed that could be reached by the new machine, which has the appearance of the ordinary racing car, except that the back part consists of a steel chamber with twelve round openings, out of which penetrate the steel pipes from which the rockets are discharged. Fuses are connected with the pipes and are linked up on an automatic switchboard, and are controlled by the driver's seat. The rockets are discharged by means of an electric spark and a sheet of flame bursts out from behind the car, which is said to shoot off at a terrific speed enveloped in a cloud of smoke. A drawback to the invention is that the rockets are very expensive. The machine is to be taken to Berlin next month for trial purposes, and the attempt will be made to beat the British world's speed record with a car that will run on rails, for which purpose the German railways are placing a suitable stretch of railway line at the disposal of the Opel Company.

CALCUTTA WATERWORKS—NEW PUMPING STATION EQUIPMENT

MESSRS. ST. GEORGE MOORE AND LA TROBE BATEMAN, M.M. Inst. C.E., WESTMINSTER, ENGINEERS

(*For description see page 423*)

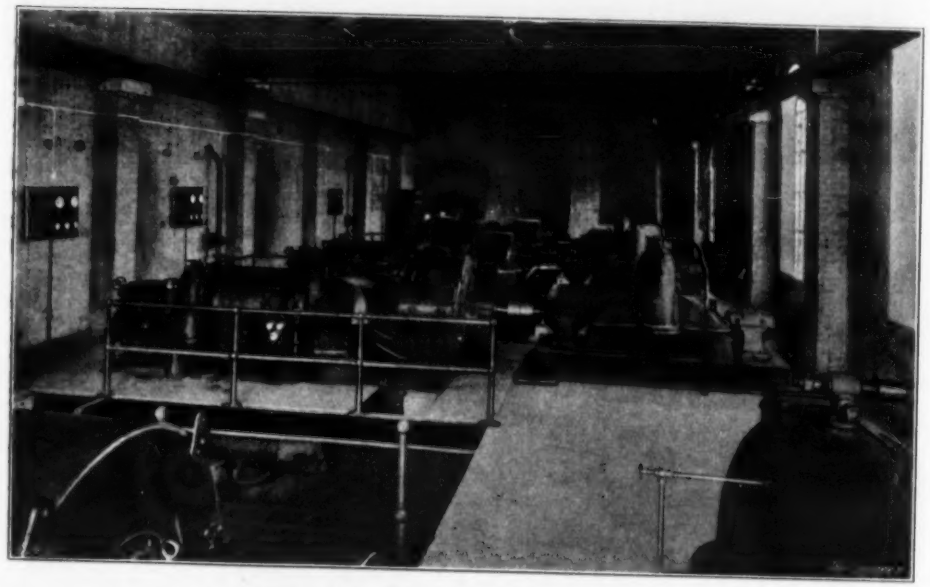


FIG. 15—TURBINES AND PUMPS AT TALLAH

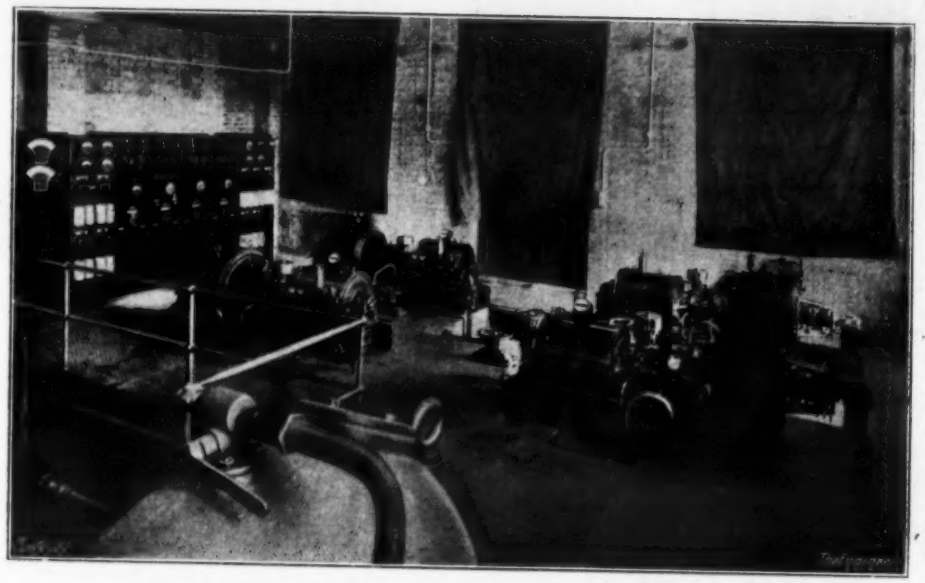


FIG. 16—ELECTRIC GENERATING SETS AT TALLAH

FIG. 17—MULLICK GHAT STATION, VIEW LOOKING TOWARDS SWITCHBOARDS

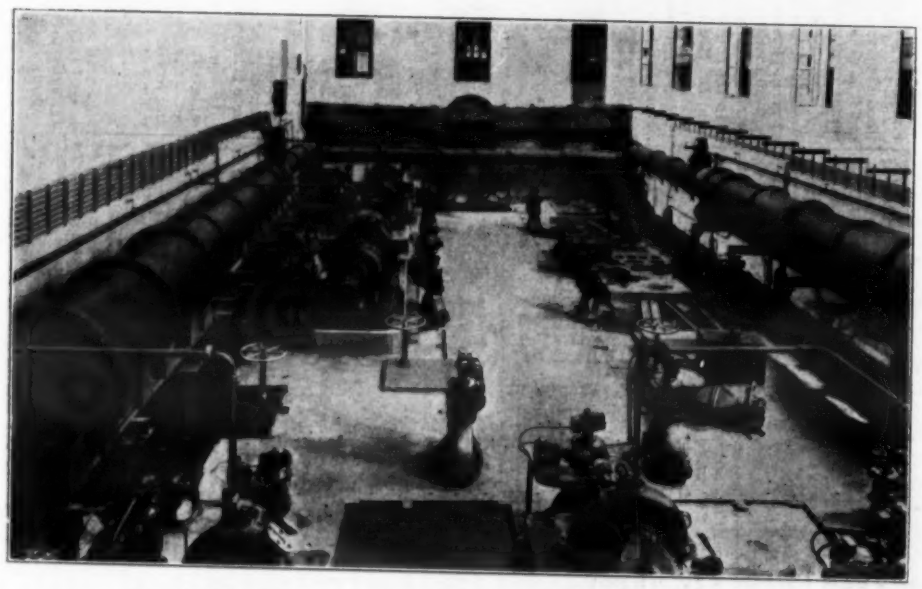


FIG. 18—MULLICK GHAT STATION, VIEW LOOKING TOWARDS RIVER

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DEATHS.

ON April 5th, at Westcliff-on-Sea, C. E. WELTON for twenty-five years manager to British Insulated Cables, Ltd., aged 66 years.

ON April 15th, S. EARNSHAW HOWELL, chairman and managing director of Howell and Co., Ltd., of Wincobank, Sheffield.

THE ENGINEER.

APRIL 20, 1928.

The Saving of Weight.

THERE are many cases of engineering construction in which the saving of weight is highly important. Bridges and roofs of great span are obvious examples of structures whose possible size is limited in some measure by their own deadweight, so that even a comparatively small saving in weight becomes important where large spans are concerned. At the other extreme are light-weight racing craft of all kinds, from the record-breaking seaplane or motor car to the light boats used in eight-oared racing. Here everything is subordinated to the saving of weight in order to lessen the power required to drive the craft forward. In this connection it is well to remember, however, that weight tells more in regard to acceleration than in the maintenance of steady speed. Once a given velocity has been attained, the effect of weight in the case of land craft only affects those frictional resistances, such as those between tire and track surface, in which the acting pressure is a definite fraction of the weight of the vehicle. In a water-borne craft, of course, weight determines the depth of immersion and thus affects the skin friction, while in the air the weight has to be sustained by the continuous expenditure of power equivalent to raising the total weight at the actual speed on a gradient of the order of one in twelve. From this brief survey of the conditions it is at once apparent that weight is far more important in the air than in any other kind of craft. Weight, however, is a consideration in many moving structures entirely apart from questions of propulsion. In road vehicles the question of wear on tires and roads depends largely upon weight as well as on speed, and thus involves the problem of running and maintenance costs. There is a similar consideration in the case of railway vehicles, although in the locomotive, as in the racing motor car, weight provides the requisite adhesion between driven wheel and track. At sea, again, weight of the ship itself and its essential parts has to be carried at the expense of useful load—cargo or passengers in the case of merchant ships, and of guns and armament generally in the case of warships. In the latter connection the limitation of the maximum tonnage of large warships has, in recent years, had the effect of causing designers to seek every possible means of reducing the deadweight of hull and machinery, with the result that the whole problem of weight has received far more attention than formerly.

Although there are cases where reduction of weight is not desirable for specific reasons, on the whole the saving of weight in moving structures of all kinds and in some stationary structures is a matter of the highest importance. The engineer who seriously desires to consider this problem of weight saving will naturally seek materials which offer the highest ratio of strength to weight and he must rely upon the metallurgist for the supply of such materials. It would almost seem, however, that some engineers seek their information on such subjects from propagandist literature or, at best, rely upon the highly conservative figures to be found in standard specifications. These two sources of information, where they overlap, sometimes disagree widely, and the engineer is apt to feel perplexed and doubtful as to the value of some special material, whether a light alloy or an alloy steel, which he has considered as a possible basis of construction. Closer co-operation with a well-informed and unbiassed metallurgist would save him much of this trouble. Anyone intimately acquainted with the real possibilities of modern materials cannot avoid feeling surprised and disappointed at the attitude towards them sometimes displayed by designers. Some degree of reserve and caution is justified; we expect it of the British engineer. It is, however, possible to push this attitude of mind too far, and as a result materials are often employed at the present time which could be improved upon to a great extent by more modern products. It has been said, with some degree of truth, that a period of eight or ten years elapses between the first discovery and development of a new material and its extensive utilisation in this country. While, then, we would urge the engineering designer to seek the fullest authentic data in regard to recent developments in materials of construction, the metallurgist also has a duty in this matter. It is his business to provide the engineer with the data he requires; that is to say, with more than test figures—even when obtained on commercially produced samples—or laboratory results. The high degree of strength in relation to weight which the engineer desires is something more than a high ultimate stress in a tensile test or even a high notched-bar impact figure. It is, indeed, difficult to define precisely what is meant by the term "strength." We are at times apt to think of "strength" as simply an abbreviation for "tensile strength," but that is obviously wrong. Engineers are interested to-day in such properties as fatigue resistance and possibly creep stresses, with or without the complicating effect, which they have just begun to recognise, of corrosion by gaseous or liquid agencies. Resistance to ordinary corrosion is itself an important factor. Excellent properties in regard to all these factors are not to be expected and are certainly not to be found at present in any one of the different types of material available to the constructor desirous of saving weight. These materials fall, broadly, into two classes—materials of high density and very high "strength," of which the heat-treated alloy steels are typical examples, and materials of low density but having "strength" properties high in relation to their weight. Of this class the high-grade aluminium alloys are the best-known examples. The choice between these two widely different types is in itself difficult in some cases, while the selection of individual materials out of the two classes is still more difficult. The ratio of tensile strength to weight per unit volume is not widely different as between the best of the alloy steels and light alloys. The alloy steels are somewhat cheaper, but demand the use, as a rule, of very thin sections, with obvious disadvantages. With the exception of the rust-resisting steels the heat-treated alloy steels appear to be seriously affected by what is coming to be known as "corrosion fatigue." As regards ordinary corrosion, it would seem at first sight that the steels are superior to any aluminium or magnesium alloys. In regard to the latter this view must be admitted, but as regards the best of the aluminium alloys when treated by a protective process such as anodic

oxidation or electro-plating, the resistance to corrosion is not inferior to that of ordinary alloy steels. The high-chromium rust-resisting steels, of course, stand in a class by themselves and are for that reason likely to find increasing structural use, although high price stands in the way of their wider employment.

These few considerations which we have briefly sketched by no means cover the subject, but they suffice to show the varied nature and the number of the questions which the engineer designer, and the engineer user also, has to consider in determining upon the materials to be employed for a specific purpose where the saving of weight is important. —questions, we may add, which receive constant attention in The Metallurgist, which is issued as a Supplement to The Engineer once a month. It is only by close co-operation with the metallurgist that the engineer will be able to find the best answer to each of these questions, and it is becoming increasingly important that he should find the right answer speedily. He has to compete to-day with foreign organisations in which the collaboration of the engineer-designer with the scientific metallurgist is very close and effective, and our British products have to compete with foreign output produced by this collaboration—to compete with them for the records of sea and sky as well as for commercial supremacy. Furthermore, we see a tendency towards the rapid growth in size and power of our units of construction, particularly where transport is concerned. It is this rapid growth in size that makes the greatest demands in the direction of weight saving. The axle loads of our big locomotives, for example, are reaching values which the steel of tire and rail, under rolling friction, can scarcely withstand. Must we solve the problem by multiplying the number of wheels and building ever larger and heavier locomotives because our passengers need larger and more luxurious trains? Or is the solution to be found in using lighter and relatively stronger materials for the construction of our trains so that the train load per passenger may be decreased or at least not further increased? This is but one of many problems that arise from the present trend of development. It is only the engineer who collaborates closely with the metallurgist who can hope to solve such problems quickly and economically.

Chimney Dust.

The pollution of the atmosphere by smoke has long been a reproach to industry. Pressure of public opinion and the efforts of local authorities, in conjunction with a more extended knowledge of the principles of combustion, have, however, brought about a considerable change for the better. To-day, apart from metallurgical works, the large coal-burning installations are among the least of the offenders. Factories and power stations have, as a rule, almost smokeless chimneys, and boiler-houses, consuming hundreds of tons of coal individually per day can be operated without giving rise to any complaints about smoke. But, unfortunately, another trouble has arisen, namely, the emission of dust from chimneys. Little was heard about it until the introduction of pulverised coal firing, when the possibility of the greater part of the ash in the fuel being distributed over the neighbourhood was frequently adduced as an argument against the new system. The advocates of pulverised fuel denied, of course, that there was any real ground of complaint on this score. That dust was emitted they could not gainsay, but they pictured it as floating away into the upper atmosphere to be deposited ultimately, if at all, as imperceptible particles distributed over some immense and distant area. Figures given as to the quantity of ash leaving the chimneys of pulverised coal plants range up to 50, or even 60 per cent. of the original ash in the fuel, a proportion as high as 25 per cent. being admitted by engineers interested commercially in the development of powdered fuel. Even on this latter estimate, a single modern boiler generating steam for 10,000 kW may easily be discharging 5 tons or more of ash per day into the air, so that the total from a large power station is something to be reckoned with. It can hardly be contended that an emission of dust on this scale may not constitute a real nuisance, in spite of all the suggestions to the contrary. Furthermore, the fact that in at least one of the large pulverised coal stations in the United States costly electrical precipitation plants have been installed, while in practically all cyclone separators are fitted to catch the dust, shows that the theory as to its harmlessness is not acceptable.

It is not to be thought that the problem of the discharge of dust from chimneys is confined to pulverised coal installations. Such plants have to answer a *prima facie* indictment, but mechanical stoking may be almost equally guilty. Indeed, if we include in the word "dust," unburned particles of carbon, it may be more so. The prevalence of dust catchers on modern stoker-fired stations, and the periodical sweepings of the roofs or gutters, often necessary where no dust catchers exist, are both recognitions of the fact that the chimneys of stoker-fired boilers may be ejecting great quantities of solid matter along with the gases of combustion. That the process is wasteful, when, as is usually the case, the grits are composed mainly of unburned carbon, is not to be disputed. But this is not the point at present. Smoke is also wasteful, but the attempts at its suppression are based almost entirely on the ground that it is a nuisance. Indeed, some years ago, to meet the complaints with regard to the smoke from one of the London power stations, the engineers had to admit excess air over the grates in such quantities that the efficiency of the plant was seriously reduced. The nuisance was abated, or at least the smoke was diluted till it appeared inoffensive; but nobody realised at what cost except those who had to pay the bill. The smoking chimney is on a different footing from the grit-producing chimney. The former advertises its offence to everyone with eyes to see it, and its tenebrous career is soon terminated in any locality where the regulations are enforced. The ejection of grit, on the other hand, is much less evident. Until it settles down, it offends none of the senses, and when it has settled the area which it affects is limited. It is a nuisance, nevertheless, and as such it should be minimised on grounds of public policy, whether or not the producers of it have any direct incentive to do so. The owners of pulverised fuel plants have personally nothing to gain by preventing the escape of dust from their chimneys, for the dust is mostly pure ash, and the more of it which will go away by itself, the less will remain to be removed from the furnaces and disposed of in other ways. Stoker-fired plants eject a large proportion of combustible matter which might profitably be burnt, yet even so the boiler efficiencies actually attained show that the loss is one which can be borne with comparative equanimity.

The question of chimney dust is becoming increasingly important, whichever method of firing is used, for the tendency to use low-grade fuel implies the circulation of more ash through the furnaces per ton of combustible matter. Not only is the ash content greater, but a greater proportion of the fuel consists of fines and dust coal. In stoker plants the forced draught necessary to burn such fuel blows a lot of it among the boiler and economiser tubes, into the air heaters, and also clean out of the chimney itself. Those who have tried to burn coke breeze, for example, mixed with coal know that the difficulty of making it burn is really that of keeping it in the furnace until it can be consumed. Even supposing this problem to be solved, there would still remain that of the incombustible dust borne away by the draught. There have been attempts on the Continent to enforce regulations limiting the amount of dust which may be emitted by a chimney. Under such regulations, we believe, it is an offence to discharge into the atmosphere more than 5 per cent. of the ash content of the original fuel. A good dust catcher should enable these conditions to be complied with, but the task of an inspector charged with seeing that the regulation was carried out would be by no means an easy one. Neither he nor anyone else could say from observation at what rate ash was being emitted at any given moment, nor how much was discharged in the course of a week. The quantity discharged can only be computed from a knowledge of the quantity of fuel burnt, the ash content of the fuel, and the quantity of ash left behind in the refuse from the furnaces and flues. These facts are only known to the operators of the plant, and in very many cases not even by them. They are, moreover, hardly likely to obtain them accurately for the benefit of any inspector, and to be used in evidence against themselves. Furthermore, the question of the discharge of combustible grit, which may easily be a more serious nuisance than pure ash, still remains open. It would appear, therefore, that any regulations are likely to be ineffective, and indeed harmful in so far as they might tend to shift the responsibility from the owners of plants to the authorities, whose duty it is to enforce the regulations. Official inspection, at best, is a nuisance which may be comparable with that which it is designed to suppress. Engineers as a body may be relied on to do everything in their power to avoid anything which might injure the public health or destroy the amenities of their neighbours, and there is always the common law to protect the rights of those who can prove that they suffer any genuine grievance from dust or grit.

Literature.

Practical Television. By E. T. Larner. London: Ernest Benn, Ltd. Price 10s. 6d.

Although practical television may be more distant than the public has been led to suppose, there is little doubt that in due course it will be possible to see distant objects and scenes outside the range of normal vision and without regard to intervening objects or other obstructions, such, for instance, as the curvature of the earth. The transmission of photographs by telegraphy is often confused with television, but the two things are really quite distinct. The telegraphic transmission of photographs is properly described as phototelegraphy, whilst the transmission of actual objects and scenes without the intervention of photography constitutes television. As the title implies, the present volume is devoted entirely to television, which is in a less advanced stage than phototelegraphy. Several methods of phototelegraphy are, in fact, in good working order, but all the television demonstrations we have witnessed have left a good deal to be desired. At the present time, however, many scientific people appear to be studying the subject of television, and it will be strange if improvements are not shortly made.

In this book, which, we believe, is the only one published in this country that is devoted entirely to television, the author deals with practically all the developments up to date, and particularly with the work of Mr. T. L. Baird, who seems to have given more attention to this matter than anyone else. But, as Mr. A. A. Campbell Swinton showed in the course of a lecture delivered before the Radio Society of Great Britain in 1924, a very fair number of scientific people have tackled the problem, although at that time at any rate the results were not very encouraging. In 1923 Mr. J. L. Baird in Great Britain and Mr. C. F. Jenkin in America demonstrated the transmission of "shadowgraphs" by television, and in 1926 Mr. Baird followed up his demonstration of the transmission of outlines by giving a demonstration of the transmission of real images. With all Mr. Baird's work and that of others, such as Dr. Alexanderson, of the America, the author of this book deals, and those who are interested in the subject should find the volume useful.

"At the time of writing," the author states, "television sets are not available to the public, but their advent cannot be long delayed. The first sets will, we may anticipate, show only the most simple scenes, a head and shoulders view of the person speaking, or possibly a simple scene, such as a few figures on a stage with a little detail, but with the rapid development of wireless broadcasting in view, we may reasonably expect that the development of television will continue steadily until results rival the perfection of the present-day cinema, and with the perfection of television allied arts, such as Noctovision, will develop." Noctovision, we should perhaps explain, is a system of television devised by Mr. Baird in which persons sitting in total darkness can be seen on the screen of a modified form of television apparatus, the result being achieved by using in place of light the invisible rays beyond the red end of the spectrum.

BOOKS RECEIVED.

Annales des Travaux Publics de Belgique, 1928, 1er. Fasc. —Février. Brussels: Goemaere, Rue de la Limite, 21. 1928.

Hand book of Structural Steelwork. 1928. Edinburgh: Redpath, Brown and Co., Ltd., 2, St. Andrew-square. Private circulation.

Jahrbuch der Deutschen Gesellschaft für Bauingenieurwesen. 1927. Berlin, N.W. 7: V.D.I., Verlag, Dorotheenstrasse 40, Germany.

Buyers' Guide to the Motor Trade in Great Britain and the Empire, 1928. London: The Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W. 1.

Transactions of the Institution of Engineers of Australia. Volume VI., 1925. Sydney: The Institution of Engineers of Australia, 16, College-street, N.S.W.

Etudes sur la Tréfilerie et ses Dérivés. Second edition, in two parts. By R. Papier. Paris (IXe): "L'Usine," 15, Rue Bleue. Price 18f. each part.

University of London, University College: Annual Report of the College Committee. London: Published by the College, Gower-street, W.C. 1. 1928.

The Year Book of the Bermudas, the Bahamas, British Guiana, British Honduras and the British West Indies. 1928. London: The *Canadian Gazette*, Ltd., 330, Gresham House, Old Broad-street, E.C. 2. Price 7s. 6d. net.

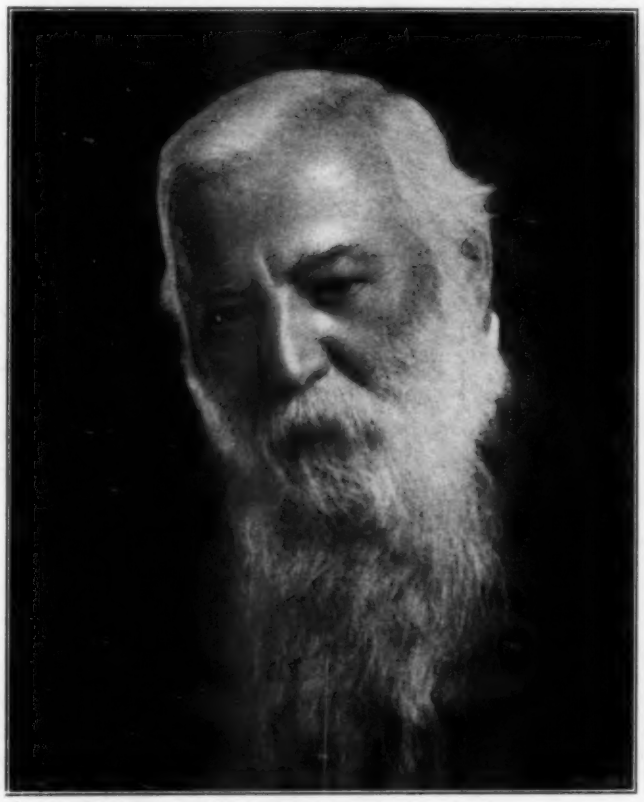
Fifty-nine Coal Mine Fires: How They were Fought and What They Teach. By G. S. Rice, J. W. Paul and M. W. von Bernewitz. Washington: Superintendent of Documents, U.S. Government Printing Office, Price 40 cents net.

Obituary.

HENRY DAVEY.

HENRY DAVEY, whose death occurred at Tavistock on Wednesday, April 11th, belonged to a school of engineers which is fast disappearing. He was born eighty-five years ago, and the scientific education of engineers was hardly thought of till he had attained middle age. In those days engineers "found" themselves; they were not "made" to the order of parents or guardians, and unless they had a real call to that profession they sought other vocations. Time and examinations have changed all that, and nowadays any youth of reasonable intelligence may be converted into an engineer—of a sort! The world requires the new system, but when we remember the class of man that grew up under the old, we have to admit that it had remarkable merits. Amongst the engineers of his generation Henry Davey stands out. He was an engineer and a mechanic by nature. Born in a part of the country which was amongst the first to be saturated with engineering and thrown into contact with engineers through his father, who was a mine captain and surveyor, as well as a schoolmaster, at Lewdon, near Tavistock, he must have absorbed mechanical principles from an early age. He used to say himself that it was the illustrated catalogue of the 1851 Exhibition which his father brought home which settled his career. He was but a little boy of eight at the time, but he became engrossed in the illustrations and descriptions. Many little boys, perhaps most little boys, are fascinated by pictures of machinery, but on all save a few it has no more than a temporary effect. But young Davey was living in the atmosphere, he was helping his father in surveys for roads and was learning in his father's school as well as in the field the application of mathematics and geometry and his love of mechanical things was genuine and inherent.

At the age of seventeen he was articled to Nicholson and Matthews, engineers, of Tavistock, and with them learnt the principles of mechanics and was made a first-class craftsman and mechanician. That he remained literally to the end of his days, for after he had gone into retirement in his beloved West Country he set up a private workshop and there as long as he was able he worked at his bench and lathe. During his pupilage he studied with a Mr. Loam, schoolmaster, of Tavistock, and showed a surprising aptitude for geometry. At Nicholson and Matthews there was another pupil, a Mr. Ingram, who had money, but lacked that real love of engineering which characterised Henry Davey. The two young men went into a kind of indefinite partnership and started making agricultural implements in Hampshire, but Davey soon tired of work which gave but little scope to his mechanical genius. He succeeded in getting a job as a draughtsman at Fox, Walker and Co.'s, locomotive builders, of Bristol, where he designed some engines for the Great Western Railway. A few years later he came to London, and he set up in practice as a consulting engineer and surveyor in the Adelphi. During this time he wrote articles for THE ENGINEER, notably on Bessemer steel and the Fairfield Works. On the visits to Sheffield and Glasgow in connection with these reports he made the acquaintance of Mr. George Bower, a financier, who was interested in new inventions. To him Davey expounded the principle of his differential pumping engine, with the result that a small engine was built and erected at Sudbury. Then came a great chance for the young man—he was under thirty at the time. Bower had acquired through the debenture holders a large interest in the Milford Haven extension scheme, which had fallen into financial difficulties. He sent Davey down to install hoist, runways and pumping engines. The plant, which Davey described in a paper read before the Society of Engineers in 1872, was a complete success, and on the completion of the work Messrs. Abels, of Derby, asked the young engineer to join them. He was unwilling to do so, and one of the Abels then advanced capital with which he bought a small foundry in Leeds. Here the differential pumping engine was rapidly developed and many orders were received. So many they were in fact that the use of additional capital became essential. It was provided by Colonel Hathorn, Davey's lifelong friend and partner, with whom the firm of Hathorn, Davey and Co., of the Sun Foundry, Leeds, was founded.



HENRY DAVEY

For many years he lived in Leeds and personally directed the works, but in 1887 he returned to London and practised as a consulting engineer to many companies and corporations, amongst which may be mentioned the Waterworks Department of the City of Birmingham, the South Stafford Mines Drainage Board, the Mitsui Company of Japan, several Cornish tin mines, the Commonwealth Portland Cement Company of Australia, and the Waihi Gold Mining Company of New Zealand. For the last named he designed extensive pumping plant for unwatering the mines. In this plant was included an engine which was probably the largest compound Cornish engine ever built. It had a high-pressure cylinder of 60in. diameter with a stroke of 6ft. and a low-pressure cylinder 110in. in diameter with a stroke of 12ft. The pumps also had a stroke of 12ft. and raised 1500 gallons of water per minute from a depth of 1550ft. The plungers were 23in. in diameter and the first plunger set was placed 700ft. from the surface.

For the same company he acted, in conjunction with Preece, Cardew and Snell, in connection with the Hora Hora hydro-electric scheme for supplying power to the mines. This scheme, which was one of the first high-tension plants in the Antipodes, started operation in 1914 and five years later was sold to the New Zealand Government. It has proved to be both from an engineering and from a financial point of view one of the most successful plants in the country. In 1908 Davey retired from active business.

Such in brief outline was Davey's career; but as it stands it gives but a very meagre idea of the work which he actually accomplished. It must be remembered that he was an inveterate inventor and that much of his life was spent at a time when there was room for the radical improvement of machines. His name will always be remembered in connection with the differential pumping engine, which was undoubtedly his most important invention, but he was always devoted to the Cornish engine and designed many improvements in its gear as well as a method of compounding it. Of the type of direct pumping engine associated with the name of his firm he was the original designer, and only a few years ago he suggested a modification which resulted in a material reduction in the total height.

The differential system was devised to meet the difficulty in non-rotative pumping engines that the load on the steam piston diminished as the steam expanded, whereas the load on the water piston remained constant. In order to compensate for this difference Davey employed an inverted triangular rocking lever. To the lower point of the triangle the steam engine connecting-rod was attached, whilst to each of the other angles the connected rods of two vertical pumps were pivoted. By this arrangement the effective leverage upon the pump rods was increased as they reach the upper limit of their stroke; that is to say, as the steam piston approached the ends of the cylinder. The principle was modified in various ways to suit different pump arrangements, and a great number of large and relatively small pumping engines were fitted with it.

It would take far too long to follow all the improvements which Davey effected in pumping engines, but we may remind those of our readers who are interested in this branch of engineering that in 1900 he published a book (C. Griffin and Co., Ltd.) entitled "Pumping Machinery," in which all the most important works of his firm are described and technical questions are treated in that straightforward way in which the author rejoiced. He had a fair, if not a profound, knowledge of mathematics, but he was a master in the handling of engineers' arithmetic and diagrams of all kinds.

Another invention of his which is not entirely forgotten is his "Safety Motor," a little low-pressure steam engine which was intended to supply householders, farmers, shopkeepers and others with small amounts of power. It was killed by the internal combustion engine and the electric motor. In its most familiar form it consisted of a vertical cast iron boiler and condenser to which was attached a little steam engine. The boiler worked at atmospheric pressure and the engine was actuated entirely on the vacuum.

In later years Davey devoted a good deal of attention to hydraulic schemes of all kinds and was the inventor of an automatic weir, which was described in THE ENGINEER of July 5th, 1912. He also inspired and helped his son Norman in the writing of a book entitled "Studies in Tidal Power," which was published by Constable's and reviewed in THE ENGINEER of February 15th, 1924.

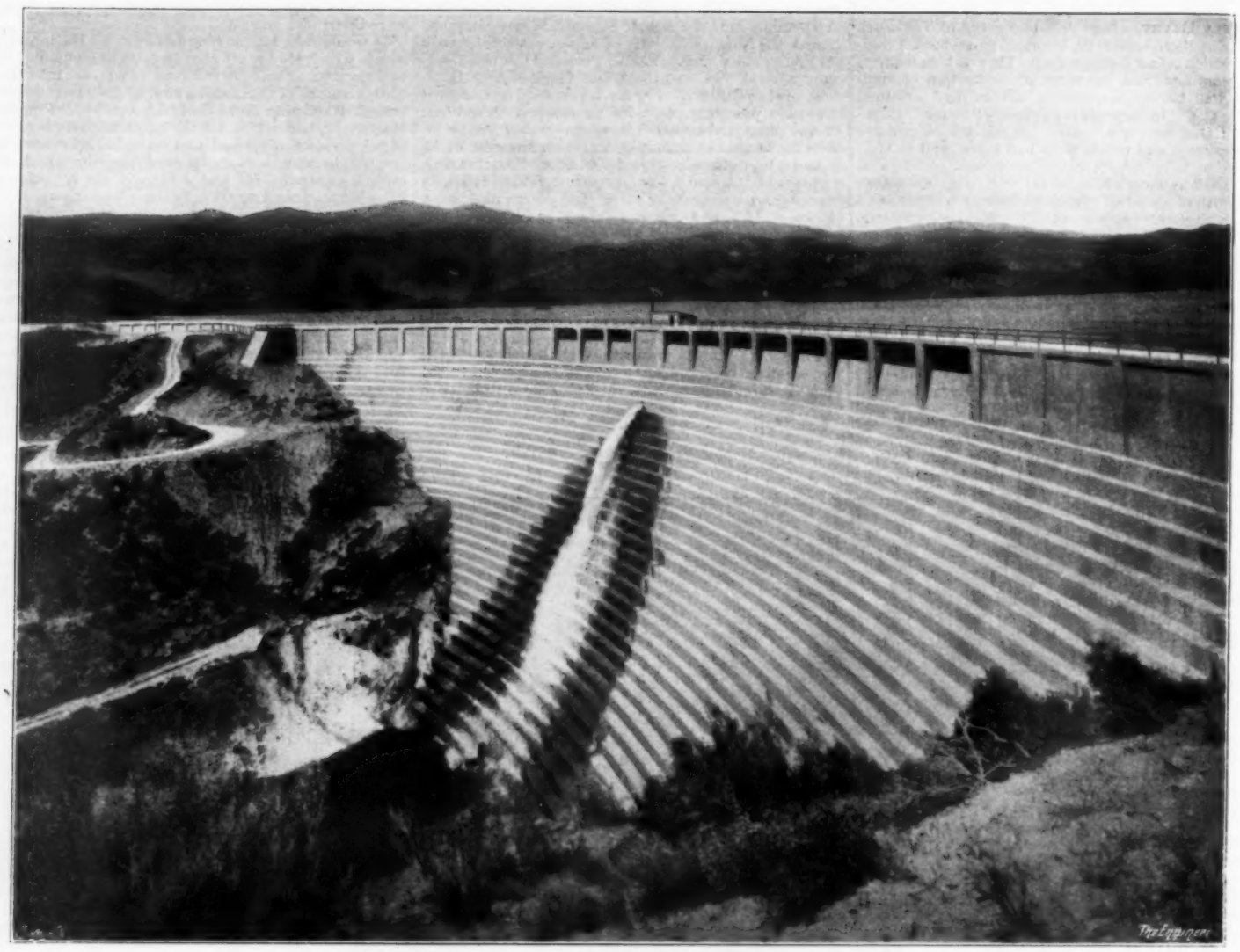
His knowledge of the Newcomen engine was no less profound than his love of it, and a paper on the subject of such engines which he read at the Institution of Mechanical Engineers in October, 1903, is full of valuable historical records. We may recall here that for many years he served on the Council of the "Mechanicals," and that he was a Vice-President at the time he retired. He was also a member of the Institution of Civil Engineers and of several other societies.

Whilst Henry Davey found time to devote to his garden and to water colour drawing, of which he never tired, he was never so happy as when talking shop, and there was no man who could talk it better. He had an excellent memory, a vast experience, and an innate feeling for what was mechanically right, and he would chat delightfully for hours to sympathetic listeners, particularly if the subject was the Cornish pumping engine. As he had an intellect far above the common and was of a very lovable disposition, such conversation brought around him, not only his contemporaries, but young engineers and often those who were not engineers at all but who were fascinated by his reminiscences and by his clear descriptions of mechanical devices. Wherever he lived he had his private workshop, and although it is scarcely right to speak of it as his hobby, for it was there that he worked out his inventions or tested principles and ideas that came to him in his professional work, yet it was, as with so many of us, a place in which he found recreation and rest. He was sometimes assisted by one or two mechanics; but, being an admirable craftsman, he did not a little of the work himself.

By his death we lose very literally a link with the past, not only because he started his engineering career nearly seventy years ago, but because, whilst keeping abreast with the present, he retained a rare devotion to that wonderful period in the development of the steam engine which was only coming to an end when he was a boy and which saw its rise in the mines of Cornwall and Devon amongst which he lived. To him and to the great firm which he founded and directed for so long the world owes more in the progress and improvement of reciprocating steam and hydraulic pumping plant than can be easily recorded.

WHAT are known as the Railway Returns—those relating to the capital, receipts, expenditure, length, business done, &c.—are issued in the autumn of each year. There is, however, a preliminary statement which shows the main figures. It appears soon after the various companies' annual reports have been issued, and it is now announced that the preliminary statement for 1927 has been published by the Stationery Office, price 2s.

THE ST. FRANCIS DAM, CALIFORNIA



View of the Dam Before the Failure

Views of the Central Section of the Dam Which Remained Intact After the Collapse

The Collapse of the St. Francis Dam.

In our issue of April 6th we gave a description of the collapse of the St. Francis Dam in California. The particulars from which that description was prepared had courteously been supplied to us by the editor of our contemporary, *Engineering News-Record*, who was also good enough to send some photographs for illustration purposes. Unfortunately those photographs, owing to some delay in the post, did not reach us until the end of last week—much too late for inclusion in our article.

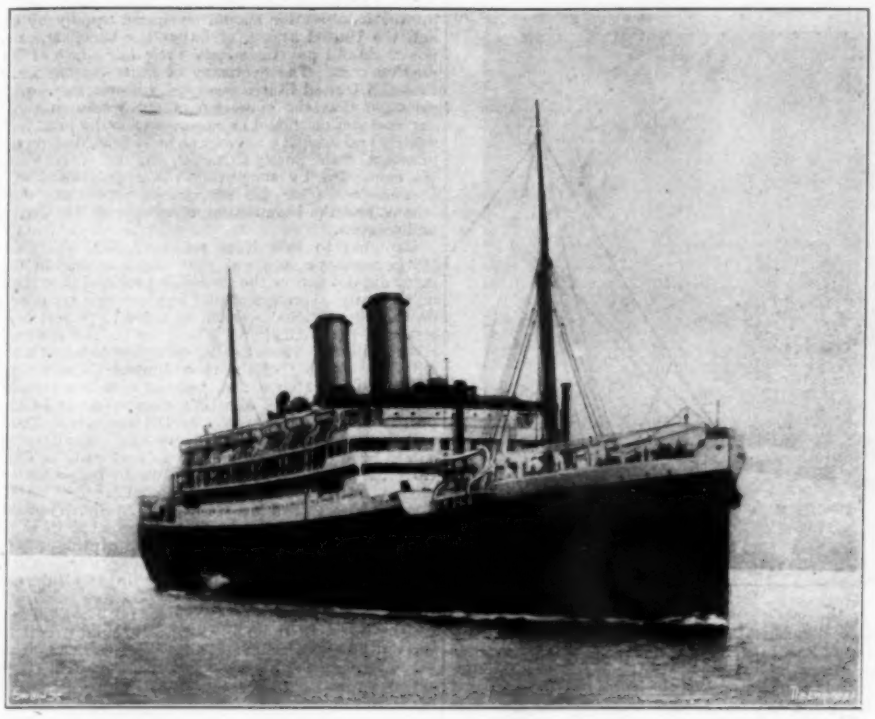
However, reproductions of three of them are now given above. The engraving at the head of the page shows the dam as it appeared on completion and prior to the failure. The other two views show the central portion of the dam which remained standing; both of them were taken from the downstream side. In both, the utter havoc wrought by the rush of water is plainly evident, and in one of them is seen the end of the low portion of the dam on the right bank which remained standing.

The Commission appointed by the Governor of California to inquire into this disaster has come to the following conclusions:—(1) Failure of the St. Francis Dam was due to defective foundations. (2) There is nothing in the failure to indicate that the accepted theory of gravity dam design is in error or that there is any question about the safety of concrete dams designed in accordance with that theory when built upon even ordinarily sound bedrock. On the contrary, the action of the middle section, which remains standing even under such adverse conditions, is most convincing evidence of the stability of such structures when built upon firm and desirable bedrock. (3) The failure of this dam indicates the desirability of having all such structures erected and maintained under the supervision and control of State authorities. . . . This disaster emphasises the fact that while the benefits accrue to the builders of such projects, the failures bring disaster to others who have no control over the design, construction and maintenance of the works. The police power of the State certainly ought to be extended to cover all structures impounding any considerable quantity of water.

While it was originally estimated that the works for controlling the waters of the river Murray, Australia, would cost about £4,000,000, the work, which is not half finished, is now estimated to cost £14,000,000.

THE ORIENT TURBINE LINER ORFORD

VICKERS-ARMSTRONG NAVAL CONSTRUCTION WORKS, BARROW, BUILDERS AND ENGINEERS



The New Orient Liner Orford.

THE new 20,000-ton geared turbine passenger liner "Orford," to which we referred in a Journal Note in last week's issue, is the fourth ship of her class to be added to the fleet of the Orient Line to Australia in the comparatively short interval of a little over three years. She was built at Vickers-Armstrong's Naval Construction Works at Barrow-in-Furness, where her sister ships, the "Orama" and "Otranto," were also constructed, and where at the present time a fifth Orient liner, the "Orontes," is well in hand. The remaining liner of the four now at sea is the "Oronsay," which was built by John Brown and Co., Ltd., at Clydebank. A full description of her will be found in THE ENGINEER for February 13th and 20th, 1925.

Although the general design of the "Orford" is similar to that of the other ships, some improvements have been made, both in the form of the hull and in details of machinery equipment. Some of the latter will be referred to in the course of the present article.

Above is a view of the "Orford" taken during her recent trials on the Clyde. She has an overall length of 658ft. with a breadth moulded of 75ft. and a depth moulded of 47ft. Her load displacement is approximately 26,000 tons, with a load deadweight of 10,000 tons and a gross tonnage of 20,000. As our illustration shows, the vessel presents a graceful appearance, to which her straight stem, cruiser stern, well raked funnels and masts, and large superstructures are all contributory factors. Like her sister ships, the "Orford" is a two-class liner. Cabin accommodation is provided for about 520 first-class and 1160 third-class passengers, and is arranged on the eight decks, three of which are continuous from the stem to the stern. The state-rooms and public room are chiefly grouped amidships on three of the uppermost decks, and the arrangement of cabins and the decorative features are so planned that, apart from her regular mail service, the vessel is suitable for making extended holiday cruises.

Safety Equipment and Deck Machinery.—The ship is provided with a cellular double bottom, which extends practically the whole length of the hull. There are four cargo holds, and a duct keel extends from No. 1 hold to the boiler-room. A very complete system of water-tight bulkheads and fireproof screens is provided, and an improved system of electric-hydraulic controlled water-tight doors has been supplied by J. Stone and Co., Ltd., of Deptford. The pumping plant for the doors calls for special mention. There are two electrically-driven rotary hydraulic pumps, the smaller of which is arranged to run continuously and to keep a constant pressure of 780 lb. per square inch in the system, so that power for opening a door is always available. In the event of a door or doors being opened, the pressure in the system falls, and when it reaches 680 lb., a hydraulically controlled cut-in switch is actuated, which starts up the large motor-driven pump, through an electric starter, and so ensures a constant supply of operating fluid at 700 lb. per square inch for all the doors in operation. When the doors are closed the pressure in the mains rises to 720 lb. per square inch, and the large pump is automatically cut out, while the small pump continues to maintain the pressure at 780 lb. per square inch.

The steering gear is of the electric hydraulic type, and is controlled from the bridge by means of telemotor gear and from the docking bridge by mechanical means.

A typical view on the boat deck is appended. This deck alone has an area of 16,500 square feet. In this illustration the MacLachlan patented gravity boat davits and the clear space out to the ship's rails can be seen. The electric boat winches may also be seen below the boats. Thirty-six lifeboats are carried, two of which are motor boats, fitted with wireless equipment. The ventilating, heating and fire-extinguishing equipment are all of the latest design.

Some of the most interesting deck machinery includes the windlass and capstan gear and the winches for the forward hatches, which were all supplied by Napier Brothers, Ltd., of Glasgow, and are designed to work on the Austin constant-current system of driving, the motors being supplied by Gilbert Austin, Ltd., of Cathcart, Glasgow. In this system a constant current—250 ampères in the case of the "Orford"—is generated, and flows in a single line series circuit from the generator, through the main switch of every motor and back to the generator. In the no-load condition the windlass circuit voltage is 2 volts and that of the winch circuit 5 volts. The full-load pressures in these circuits are 300 and 100 volts respectively. A main switch introduces the motor to the circuit, but a cam-operated by-pass switch at the controller prevents the flow of current through the windings at the off position of the controller. When the controller is moved in either direction, the current flows. Part of it is used to excite the field. The exciting voltage is under 10 volts and the field current is automatically regulated by a small regulating motor armature carried on an extension of the main shaft, through which the exciting current passes. The motor attains a torque and speed in either direction, according to the position of the control lever, and it can be run at any speed from a mere creep up to the full speed for which it is adjusted.

The function of the generator plant, which consists of two motor generators with exciters, is to see that the line is supplied with the correct current. As the motor or motors start, speed up, slow down and generally perform their work, they set up in the line a counter voltage, which would have the effect of reducing or increasing the current. In order to counter such an effect, the generator is provided with a quick-acting exciter, the object of which is to raise or lower the voltage of the machine according to the demand of the motors for energy. In this way the current through the motors is kept to an average of 250 ampères, while the voltage varies up and down according to the fluctuation in load. The system requires no fuses, the motor can be overloaded until it stops but no damage ensues, and the pull of the motor is actually increased. With a stalled motor the load on the generator is reduced nearly to zero, as the counter voltage of the motor being wiped out, the exciter reduces the generator voltage accordingly. The motor can hold a suspended load stationary with only a nominal load on the generator, and is claimed to be foolproof as regards its operation. The constant current system has enabled the windlass builders to design an all-spur gear windlass with a high efficiency. It is in two sections, port and starboard, and has two motors, one for each section. As the forward capstans are driven from branch shafts, the same motors may be employed to drive either the windlass or capstans.

For handling the cargo at the forward holds, six motor-driven worm gear type double winches are provided. They are designed to lift 2½ and 5 tons. The two generators each have a capacity of 75 kW at 250 ampères, with a voltage varying from zero to 300 volts. Only a very simple switchboard is necessary. The two generators can be operated in the following ways:—One on the windlass and one on the winches, either machine on both the winches and the windlass, or both machines coupled in alternate series on the loads. The generators operate as a flexible buffer between the drastic deck machinery load and the ship's power supply. Thus, when recently docking at Belfast, both capstans were employed, each with a motor of 100 B.H.P., yet only one 75-kW generator was used and the peak loads of about 200 B.H.P., which came on at times, were converted into a maximum demand of only 85 kW on the ship's generating plant.

Propelling Machinery.—The vessel is propelled by two sets of single-reduction geared turbines of the Parsons type. Each set comprises a high-pressure, intermediate-pressure and a low-pressure turbine. They work in series and drive separate pinions engaging with the main gear-wheel. The high-pressure turbine is of the impulse reaction type, the first stage consisting of a wheel with two rows of velocity compounded blading of 65in. pitch circle diameter. This wheel is followed by four expansions of reaction blading, with a height of 1¾in. to 2¾in. mounted on a 33in. diameter hollow drum. In the intermediate-pressure turbine there are five reaction expansions with blades from 2¼in. to 6¾in. high, mounted on a 36in. hollow drum. The high-pressure astern turbine is also carried in the intermediate-pressure casing, and it consists of a 65¼in. impulse velocity compounded wheel. A single-flow low-pressure turbine is employed with nine stages of reaction blading, having blade heights of from 4in. to 11in., which are mounted on five 60in. diameter wheels. The remaining part of the astern turbine is accommodated within the low-pressure turbine casing, and consists of a two-row velocity compounded wheel of 65¾in. diameter, followed by five stages of reaction blading having heights of blade ranging from 2¼in. to 5in.

VIEW ON THE BOAT DECK OF THE ORFORD

All the turbines are designed to run at 1372 r.p.m., and the total designed output of the two sets is 20,000 S.H.P. at this speed, which corresponds to a propeller speed of 95 r.p.m. The astern turbine power is 75 per cent. of the designed ahead power. Below the exhaust flanges of the low-pressure casings are the "Contraflo" surface condensers. They are arranged for a working vacuum of 27¾in., at a 30in. barometer and with 86 deg. Fah. sea temperature.

Steam is generated in six 16ft. 6in. diameter double-

PAVEMENT BREAKING MACHINE

B. JOHNSON AND SON, ILKLEY, ENGINEERS

ended and two single-ended boilers of the return tube type, which are arranged in two boiler-rooms. They are equipped with Wallsend-Howden oil burners and work under forced draught. The total heating surface is 46,530 square feet, and saturated steam is supplied to the turbines at a working pressure of 215 lb. per square inch.

With the exception of the main reciprocating circulating pumps, a few other service pumps of this same type and two steam turbine-driven main feed pumps, all the other service pumps and the forced draught fans are electrically operated. The electric generating equipment includes three 400-kW, 220-volt, direct-current turbo-generator sets, supplied by W. H. Allen, Sons and Co., Ltd., of Bedford, and a 36-kW oil-driven emergency set is accommodated in a house on the boat deck.

Trial Results.—The trials, which were made on the measured mile at Skelmorlie a few weeks ago, showed, we are given to understand, that the modifications made to the form of the hull in this ship have given a marked improvement in propelling efficiency. On the twenty-four hour full power trial, with the ship steaming at a speed of 19 knots, the fuel consumption for all purposes was only 0·785 lb. of oil per S.H.P. hour, while on the low-power trial the consumption worked out at 0·92 lb. The "Orford" sailed on Friday last for a cruise to the Mediterranean, and she will be engaged in making similar cruises and cruises to the Atlantic Islands and Norway and the Northern capitals until October next, when she is scheduled to take up her regular Australian mail service.

A Pavement Breaking Machine.

We recently had an opportunity of inspecting at work a rather novel machine, specially designed for breaking up old concrete pavements, which is illustrated by the engraving above.

This machine, which is made by B. Johnson and Son, of Wharfendene, Skipton-road, Ilkley, Yorks, works on the principle of a falling weight driving a sharp pointed pick into the concrete and splitting it up into pieces of such a size that they can be man-handled. It is driven by a 12-14 horse-power Petter vertical crude oil engine.

The weight, it will be seen, is lifted by a "board," like a drop stamp, and the whole of the mechanism is mounted on a rotating frame, while power-driven travelling wheels are provided, so that a series of arc-shaped cuts are made as the machine progresses. The design of the underframe requires little comment, but it may be pointed out that steering is effected by a hand wheel on the near side of the machine which is manipulated by a man walking alongside. As the machine generally works along a straight line this arrangement is quite convenient, and has the merit of simplicity. The driving wheels are 48in. in diameter by 8in. wide.

The revolving frame is built up of steel channels, and is pivoted, near its centre, on a saddle casting, which has a pivot bearing on the main axle. A large toothed ring and pinion are provided for the rotating movement. On this frame there are mounted the engine, all the gearing, the driver's control station and the gear for lifting the weight. The driver, by the way, has a view of the pick between the two sides of the frame.

The falling weight, which amounts to some 10 cwt., has a stroke of 3ft., and makes fifty blows per minute. The board is of tempered spring steel, and, of course, represents part of this weight. On either side of the board there is a transverse shaft, and the two are geared together, so that they rotate in opposite directions. At the centre of these shafts there are two plain faced wheels with about half their circumference cut away. The remaining part of their rims is faced with Ferodo. These parts of the rim bear against the board, and the necessary pressure is obtained by mounting the shaft bearings in slides and pressing them together by strong springs. In ordinary operation the two wheels are kept running continually, and as their rims grip the board they raise it. When, however, they have rotated so far that the gaps face the board, it is quite free to fall and the blow is struck by the pick. It is naturally sometimes necessary to hold the board at the top of its stroke, and for this purpose two excentric grips are arranged on shafts at the top of the board guides. These grips are pressed against the board by springs in such a way that they prevent its descent, but allow it to rise freely. There is a link connection from the grips to the driver's station, so that he can keep them out of engagement during normal working. Towards the bottom end of the board there is a part of reduced thickness, so that when it is raised with this part opposite the centre line of the lifting wheels, and is held by the excentric grips, the lifting wheels can be kept in rotation without rubbing on the board. There is also a powerful friction clutch in the drive, so that the whole of the lifting gear may be stopped with the engine still running. The drive is effected by the belt seen in the view of the machine.

The gear for swinging and travelling the machine is arranged between the engine and the driver's station, and is driven off the main shaft by chains on the near-side of the machine. It comprises two sets of reversing gear of the double bevel type, with dog clutches for obtaining movement in either direction, and the toothed wheels necessary for connecting up with the swinging pinion and the travelling wheels through the centre pivot. The clutches are, of course, operated from the driver's station. The weight of the whole machine is 6½ tons.

On the occasion of our inspection the machine was at work at the Royal Albert Docks breaking up an old concrete pavement about 6in. thick, and we were really surprised at the rapidity with which it progressed. We have no definite figures as to its capacity, but some idea may be gathered from the fact that three or four blows of the pick were sufficient to break off a mass of concrete that two men could barely handle. This was done with plain concrete, and we understand that almost as good progress can be made with reinforced pavements, as the layer of concrete above the reinforcement first breaks away and then the layer below can be tackled.

The St. Lawrence Development.

The correspondence exchanged between the Canadian and United States Governments about the proposed St. Lawrence power and navigation development scheme was laid on the table of the Dominion House of Commons on April 16th. Both Governments agree that a basis of negotiations has been reached for proceeding with a huge scheme, involving a 27ft. waterway to the head of the Great Lakes, the development of approximately 3 million horse-power and an expenditure of approximately 650 million dollars.

The main proposals are that Canada should construct and control the wholly Canadian section of the St. Lawrence shipway, including the new Welland Canal, at a total expenditure of approximately 315 million dollars, and the development of approximately 1 million horse-power, this power development to be exclusively for Canadian use, while, on the other hand, the United States should construct the international section of the St. Lawrence River and complete the Upper Lake channels to a depth of 27ft., at a total estimated cost of 339 million dollars. The power development of the international section, it is estimated, would be 1,602,000 horse-power, to be shared equally by Canada and the United States.

Attention is drawn in the Canadian proposals to the fact that Canada has already spent 85 million dollars on improvements in the St. Lawrence and Great Lakes shipway, while the United States has spent 44 million dollars. Thus, when the proposed new development is carried out, the total expenditures on the whole shipway would approximate 400 million dollars for Canada and 383 million dollars for the United States. The Canadian Note further points out that the new locks on the St. Lawrence River should be of a depth of 30ft., having in view a possible subsequent enlargement of the whole waterway to the same depth to the head of the Lakes.

The United States Secretary of State, Mr. Kellogg, replying on March 12th to the Canadian Note, said that while the Washington Government was not in complete agreement with the Canadian Government's representations in respect of the relative benefits and ultimate costs and division of expense to be borne by each country, it was inclined to regard as an acceptable basis for negotiations a proposal along the general lines suggested. Mr. Kellogg proposed that the power development cost of the international section should be shared equally by Canada and the United States, and that the beneficiaries of the power should pay ultimately their fair share of its production cost. The Secretary of State further intimated that the United States accepted without reservation the principle that the operation of the works in the international section should be constructed under joint technical control and in such a manner as to safeguard all navigation interests on the purely Canadian sections of the waterway. He concluded by suggesting the appointment of Joint Commissioners for the purpose of proceeding with the scheme and the formulation of an appropriate Convention and treaties.

Replying to this Note on April 5th, the Canadian Government pointed out that the Washington Government did not favour the Canadian proposal that the works on the national section should be given priority over works on the international section, in order to permit a further study of the engineering difficulties on the international section, and also to make the power development keep pace with the capacity of the more limited Canadian market to absorb it. It was also pointed out that certain constitutional questions affecting circumstances in Canada, particularly with reference to the respective Provincial and Federal rights in the St. Lawrence power development would have to be clarified, and to that end the Canadian Government stated that a case would be presently submitted to the Supreme Court of Canada.

A final Note from Mr. Kellogg on April 7th agreed with the procedure of the Canadian Government in respect of Supreme Court submission, and also with the proposal for a conference of a joint board of engineers to consider further the engineering problems in the international section.

The United States Note concludes: "The United States will be prepared to co-operate to the fullest extent with the Canadian Government at any time for the purpose of accomplishing the improvement contemplated."

The Quarter's Shipbuilding Returns.

From the statistics issued by Lloyd's Register of Shipping regarding vessels under construction at the end of March, we learn that in Great Britain and Ireland there was a reduction of about 139,000 tons in the work in hand, as compared with the figures for last December, which were the highest reached since September, 1922. The present total—1,440,842 tons—is, however, about 224,000 tons higher than the tonnage being built at the end of March, 1927. It may be of interest to state that just over 228,000 tons of the tonnage now being built in this country will be registered in the British Dominions, while about 177,000 tons are intended for sale or for foreign shipowners.

The tonnage being built abroad, 1,452,409 tons, is slightly higher than the tonnage being built in this country, while at the end of December the combined tonnage being built abroad was about 40,000 tons less than the total for Great Britain and Ireland. Only five countries abroad have more than 100,000 tons under construction, viz.:—Germany, 443,939 tons; Italy, 171,016 tons; Holland, 162,973 tons; France, 103,494 tons; and Denmark 103,110 tons. It may be stated that the present world total of 2,893,251 tons, although higher than the average for the last five years, is still 410,000 tons lower than the average reached during the last twelve months before the war. In Great Britain and Ireland 341,843 tons were commenced and 406,726 tons were launched. Similar figures for abroad are 263,580 tons commenced and 253,222 tons launched. It will be seen that while in Great Britain and Ireland some 65,000 tons more were launched than commenced, abroad the tonnage launched was 10,000 tons less than the tonnage commenced.

A reduction is shown in the tanker tonnage under construction as compared with the very high figures reached during the previous two quarters. The present figures are ninety-five vessels of 637,232 tons, of which 276,462 tons were building in Great Britain and Ireland; 76,850 tons in Denmark; 75,820 tons in France; and 70,500 tons in Sweden. While in Great Britain and Ireland the tonnage of motorships under construction—573,546 tons—is still considerably less than the tonnage of steamers being built, abroad the motorship tonnage reaches 917,321 tons, as compared with 527,522 tons of steamers. The world figures for motorships actually exceed by 100,000 tons the total for steam tonnage. The striking progress of the internal combustion engine is also indicated by the figures respecting the indicated horse-power of oil engines, which, at the end of March, were either under construction at the works or being fitted on board, viz.:—1,333,875 horse-power.

The pre-eminent position which Lloyd's Register retains amongst the Classification Societies of the world is strikingly demonstrated by the fact that the tonnage being built throughout the world under the inspection of Lloyd's Register reaches 2,000,480 tons. The tonnage in Great Britain and Ireland intended for Lloyd's Register class is 1,290,578 tons, and represents practically 90 per cent. of the total being built in this country. Taking the world's figures, nearly 70 per cent. of the total tonnage is under the survey of Lloyd's Register.

Institution of Automobile Engineers.—The Council of the Institution of Automobile Engineers has decided to award the Institution Medal to Major G. S. Wilkinson, M.I.A.E., for the prominent part which he took in the design of the Napier Lion 875 H.P. engine fitted to the winning machine in the Schneider Trophy Race. The Council has also decided that in future the award of the medal shall be extended to non-members of the Institution, for technical achievements of special value.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

AUTOMATIC SUB-STATIONS.

Sir,—I am rather late in referring to the leading article in The Engineer dated March 9th. As, however, I believe there is another side to this question, perhaps you would be good enough to publish the following, which is the substance of my contribution to the discussion on Mr. Poynder's paper at Manchester :—

"We must thank Mr. Poynder for giving us this paper on automatically controlled rotary sub-stations, and no doubt such papers and discussions thereon help pave the way to improvements in operation.

"However, we must be careful that in criticising our own work we do not cause others to lose sight of the good service which is being rendered in all parts of the world by these automatically controlled stations. I mention this because this paper has resulted in English manufacturers being unduly criticised for installing automatically controlled rotary converters rather than automatically controlled rectifier equipments.

"A careful analysis of the rectifier on the Continent, England and elsewhere will not lead engineers to the belief that such equipments have reached the standard of maintenance and operation that is expected and has been obtainable for years from rotary converters manufactured in this country and operating on all voltages up to 1500 volts. These remarks apply to countries where the climatic conditions are easy and accommodation for cooling the rectifier good.

"When one remembers the importance of some of the large railway electrifications undertaken by British firms and that these schemes have necessitated sub-station equipments capable of withstanding high load factors with superimposed overloads, operating in climates where the sub-station temperatures vary from minus 15 deg. Cent. to plus 50 deg. Cent. and where water has been scarce or commercially impossible to acquire, it will be realised that there is good reason why rotating machinery has been chosen in preference to the rectifier.

"When the rectifier has developed to a state when it will operate on high load factors and carry heavy overloads without risk of backfire, when satisfactory methods have been found for the elimination of telephonic disturbances in the difficult cases as well as the easy ones, when cooling for the vacuum chambers can be obtained with reasonable certainty of not being affected by climatic conditions or corrosion, then undoubtedly the rectifier will find a field on some 1500-volt direct-current electrifications, and certainly on 3000-volt direct-current systems the operating efficiency would be much improved by their use. Engineers, however, would be shutting their eyes if they assume that these difficulties are at present solved.

"Several of the large electrifications that have been installed in the last few years have been supplied from generating stations with little or no load other than the railway load. With the distorted wave shapes of alternating current flowing in the rectifier it is doubtful whether such a load could be handled by the generating equipments without causing serious losses in the generators. It will be realised that this is a condition different to where only a relatively few rectifiers are connected to a large system."

F. P. Whitaker.

Rugby, April 12th.

ALTERNATING CURRENT FOR MAIN LINE RAILWAYS.

Sir,—I was much interested in your leading article on the 6th inst., regarding the use of alternating current for long-distance railway schemes.

Had the engineering experts of thirty or forty years ago been asked to standardise what, in their opinion, was the best system for generation and distribution for lighting and power purposes, they would, with very few exceptions, have decided that direct current was the only system worth considering, whereas to-day the alternating-current system of generation, transmission and distribution is being standardised in this country.

I cannot help thinking that in the near future further improvements will be made in alternating-current motors and methods of change of phase and periodicity which will considerably enhance the use of alternating current for long-distance traction—as distinct from suburban traffic—owing to its flexibility and simplicity in transmission and transformation.

I therefore consider it would be unwise to shut the door to the alternating-current system in the future.

G. W. Partridge.

London, S.W. 1, April 17th.

A New Cross-Cutting Saw.

The illustration which we give above represents a new form of log cross-cut saw which has recently been brought out by A. Ransome and Co., Ltd., of Newark. It is really a development of the tree-felling saw made by the same company for many years past, and should, as a consequence, prove very useful.

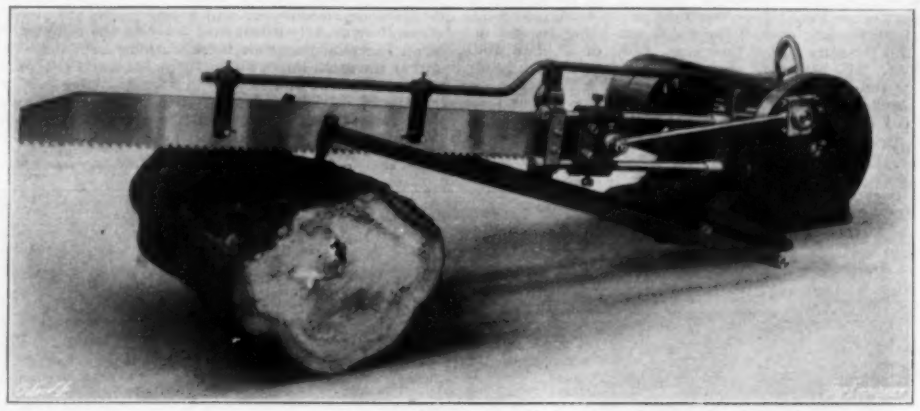
The cross-cutting saw is intended for mill work, and is mounted on a bed for bolting down to the floor, while it is driven by belting.

The saw itself is fixed to a sliding crosshead attached to a connecting-rod driven by a balanced disc crank. It usually cuts on the inward stroke only, so that all possibility of buckling is avoided ; if preferred, however, blades for cutting on both strokes can be supplied. Two guides are provided to hold the saw steady until it gets into the cut, and are adjustable on a hinged tubular rod. The upward thrust of the saw is taken by a hardened steel grooved roller. The crosshead slides on two turned steel guide rods, the outer ends of which are connected by a steel saw guide block provided with packing plates which are adjustable. The saw frame is pivoted on hollow trunnions through which the crank shaft runs. On the trunnion there is fixed a worm wheel, which engages with a worm and hand-wheel for feeding the saw into the cut. By the same means the saw can be raised into a vertical position, so as to leave the floor space in front clear for the manipulation of the logs. Two spikes on radial arms are provided for steadying the log during the process of sawing.

This machine has also been fitted for use with a chain drive and electric motor, and mounted on road wheels for work in the field. It will cut logs up to 72in. in diameter, runs at 100 revolutions per minute, and requires 5 horse-power.

LOG CROSS-CUTTING SAW

A. RANSOME AND CO., LTD., NEWARK, ENGINEERS



SOCIETY OF CHEMICAL INDUSTRY.

A Chemical Industry Conference has been organised by the Society of Chemical Industry in co-operation with its London Section and Chemical Engineering Group and the Institution of Chemical Engineers, and will take place in London on May 11th to 15th, 1928.

The programme is as follows :—On Friday, May 11th, the annual meeting of the Chemical Engineering Group will be held at Les Gobelins Restaurant, 1, Heddon-street, Regent-street, London, W. 1, at 6 p.m., the annual dinner following at 6.30 p.m. At 8.30 p.m. an address will be given by Mr. Francis H. Carr on "Some Chemical Engineering Aspects of the Fine Chemical Industry."

On the Saturday a visit will be paid to the Rothamsted Experimental Station, Harpenden, starting at 9.30 a.m. by motor coach from Dorset-square. On the Sunday the gardens of the Zoological Society, Regent's Park, will be visited.

On Monday, May 14th, a conference will be held in the Hall of the Institution of Civil Engineers, Great George-street, Westminster, S.W. 1, beginning at 10.30 a.m., the chairman being Sir Hugo Hirst. The following papers will be considered :—(1) "The Fuel Industries and the Work of the Chemical Engineer," by Sir Arthur Duckham ; and (2) "The Chemical Study of Low-temperature Tar," by Professor G. T. Morgan, F.R.S. In the afternoon, at 2.30 p.m., under the chairmanship of Lord Desborough, two further papers, (1) "Water Purification," by Sir Alexander Houston ; and (2) "The Pollution of Tidal and Non-tidal Streams," by Mr. J. H. Coste, will be taken. The Chemical Industry Conference dinner will be held at the Connaught Rooms, Great Queen-street, W.C., at 7 p.m. and will be followed by a dance.

On the Tuesday, May 15th, the Conference will be continued in the Hall of the Institution of Civil Engineers. The British Science Guild has been invited to participate in this meeting, and tickets will be sent by the Guild to any of its members who may wish to be present. At the morning session, beginning at 10.30 a.m., the following papers will be presented :—(1) "Scientific Research as Applied to Industry," by Sir Alfred Mond ; and (2) "The Part Played by British Workers in the Application of Fixed Nitrogen to the Soil," by Sir John Russell, F.R.S. At the afternoon session at 2.30 p.m., under the chairmanship of Lord Bledisloe, a paper on "Developments in the Heavy Chemical Industry" will be read by Lieut.-Colonel G. P. Pollitt, D.S.O.

SIXTY YEARS AGO.

We are apt perhaps to regard the conditions under which our fathers and grandfathers became engineers as easy, and the opportunities which they found for advancing themselves in their profession as multitudinous. The education, technical and scientific, of an engineer to-day appears prolonged, complicated and difficult as judged by comparison with what we picture to have been the case sixty years ago. It is, however, fairly certain that, as the knowledge required has increased, the means of acquiring it have been made easier, and that, on balance, it is no more difficult to-day to fit oneself to be an engineer than it was in the 'sixties. That it was no easier then than now to secure advancement, seems to be inferred by repeated references to the subject in our own columns of that time. Reviewing the position in our issue of April 17th, 1868, in a leading article designed "to give a few words of counsel to young men determined to adopt engineering as a profession," we referred to the large number of letters which we received appealing to us for advice as to the best branch to adopt and the best means of mastering its details. We continue to receive many such letters, and find them no easier to answer than did our fore-runners. Our general advice in 1868 was of a discouraging kind. The ranks of the profession, we said, were "fearfully overstocked," but prudent counsel against still further swelling them would, we recognised, be as unavailing as *Punch's* advice to those about to marry. Our counsel was designed, not to show the budding engineer how to acquire fame or fortune, but how he might avoid ruin. To that end we cautioned him against indulging in day-dreams in which he saw himself revolutionising the mechanical world. His duty, as an ordinary or average engineer, was not to invent or improve on his employer's productions but to make them for sale at the lowest price consistent with good and honest manufacture. We did not hold that what was, was right in all cases, but in the majority of instances the work turned out by good firms and the method of turning it out was either absolutely right or, at least, better than anything which a man necessarily lacking in experience could devise in their stead, whatever an ingenious pupil might think. We urged would-be engineers to seek their practical training in small establishments, the masters of which in innumerable cases possessed great shrewdness, no small skill, and a remarkable aptitude for making things pay. In such an establishment the pupil would have a much better opportunity than in a large works of learning the cost of the finished product, a subject of study to which we accorded very great importance.

THE ENGINEERING INSTITUTE OF CANADA.

Approximately 1000 persons attended the forty-second annual convention of the Engineering Institute of Canada, held in Montreal, Quebec, on February 14th, 15th and 16th. Engineers were present from all parts of the Dominion, and some from the United States. The presence of His Excellency Viscount Willingdon, Governor-General of Canada, at the annual dinner, was a notable feature of the meeting. A number of highly interesting and informative technical papers were presented, and were followed by discussions. Part of the time was devoted to social activities and to making tours of the city, visiting outstanding engineering works and industrial plants.

Two of the papers presented were on aspects of the Welland Ship Canal. Mr. Frank E. Sterns, designing engineer of the canal, described the locking arrangements ; and Mr. A. J. Grant, Engineer-in-Charge, pointed out that when completed about 1930 the canal will be the fourth built by Canada during the past 100 years across the Niagara Peninsula for the purpose of connecting Lakes Erie and Ontario. The canal, he said, will also be the largest link in the proposed ship canal project connecting the Great Lakes with the Atlantic Ocean *viâ* the St. Lawrence River. "The Welland Ship Canal," he declared, "is one of the most important engineering works in hand at present in the British Empire and North America."

Another interesting paper presented was that dealing with the steel work of the new Royal Bank Building, in Montreal, submitted by Mr. R. M. Robertson, structural designer of the Dominion Bridge Company. He stated that there would be 20 floors in the building, including sub-basement, basement and pent-house, but that the building was generally recognised as a 23-storey structure. Seven floors, the sub-basement, basement, main mezzanine, first, second, and truss, are situated in the lower portion of the building. Fifteen typical office floors occupy the portion between the two set-backs ; and in the tower above the second set-back there are two office floors in addition to the pent-house.

His Excellency Viscount Willingdon paid homage to Canadian engineering skill, saying that, when he was in the Presidency at Madras, it was to Canada they looked for forestry engineers. He also expressed the hope that Canadian money and Canadian engineers, or, at any rate, money and men of the British Empire, would be used in future in all Canadian engineering undertakings.

Mr. Julian C. Smith, vice-president and manager of the Shawinigan Water and Power Company, Shawinigan Falls, Quebec, was elected President of the Institute for the ensuing year, succeeding Mr. E. R. Decary in that office.

A New Air Pressure Piling System.

On Friday last, April 13th, we inspected on the site of a new seven-storey warehouse which is to be erected at Three Cranes Yard, Upper Thames-street, some interesting reinforced piling operations which are being carried out by the Pressure Piling Company, Ltd., of 50, Pall Mall, S.W. 1. The basement of the new building is already 9ft. below the street level and the piles, which are sixty-four in number, are pitched at about 4ft. intervals, and are carried down to the blue clay, a depth of some 40ft. The method of piling which is being employed is claimed to be particularly suitable for such a site, as no vibration is transmitted to adjoining buildings on each side, up to the footings of which it is necessary to work.

The process consists of, first of all, inserting a steel tube into the ground to the required depth, removing the core and subsoil water, and then gradually withdrawing the tube by air pressure and filling the vacated space with concrete, which is forced into the surrounding soil by compressed air at 100 lb. per square inch pressure. In this way a clubbed foot is formed at the root of each pile, and the bores made on the site we inspected showed that in some cases bottoms of the piles were actually interconnected, though, as has been said, they were at 4ft. centres. Further, as the steel tube is withdrawn the air pressure drives the concrete into the interstices of the yielding strata and collars are formed round the surface of the pile, which greatly increase the skin friction of the latter.

Fig. 1—Head and Foot of Pile made on the Air Pressure System

Fig. 2 shows the operation being carried out on the site named, while Fig. 1 shows the top and bottom portion of a pile, which was excavated for the inspection of the Government of Northern Ireland Authorities during the recent underpinning of the Belfast Custom House on the pressure piling system.

The method of sinking the steel tube is akin to that of well boring, and, incidentally, it enables the character of the strata through which the pile is to pass to be explored. The first tool used is an auger bit, and it is followed by the first steel tube, which is provided with a sharpened under lip. Each of the tubes has a screwed end to form a flush joint and a 12in. internal diameter. Lengths of from 8ft. to 10ft. are employed, which are "surged" down by alternately slightly lifting and lowering the tube by means of an Ingersoll-Rand air hoist working on a light tripod, and at the same time twisting it by the hand-twisting clip seen at the foot of the tube in Fig. 2. After one or two lengths of tube have been inserted, the core is removed by a close fitting steel cylinder, which is arranged inside the tube and is provided with a clack valve at its lower end through which the excavated material passes during the "surging" operation. The result is that, gradually, the cylinder becomes full of the *débris* and it is then drawn up and emptied. The sequence of the operations is then repeated until a weight bearing stratum is reached.

In the particular operation we are describing the tube is carried down sufficiently far into the blue clay to seal off the sandy ballast and subsoil water, which is found immediately above the surface of the clay.

When the desired depth is reached—in the case we saw it was about 40ft.—reinforcement is lowered into the steel tube. In the piles the sinking of which we witnessed, it consisted of six steel rods, each ¾in. in diameter with spiral bindings. The reinforcement was, in view of the length of the piles, in two sections, spliced together. Distance pieces are employed to keep the reinforcement in a central position.

Fig. 2—Pressure Piling Operations in Progress

As soon as the reinforcement is placed in position, a pressure cap is screwed on to the top of the uppermost tube. This cap is furnished with two ¾in. air hose connections, a 1in. safety valve, hand-operated by a cord, and a central gland through which is threaded a 1¼in. diameter steel tube. This tube is pushed down through the centre of the reinforcement to the bottom, and when compressed air is admitted to the inside of the pile tube, through one of the hose connections mentioned above, the subsoil water and any *débris* remaining is blown out of the cavity through this centre tube. Before this is done a Bougie pan, consisting of a steel pressure container with a hand-stirring device, is filled with concrete grout, and is connected to the pressure head through the second hose connection. As soon as the water has been blown out, a cock on the centre pipe is closed and air pressure at 100 lb. per square inch is applied to the Bougie pan, and its contents are transferred to the space within the pile tube. The pressure cap is then removed and the centre pipe withdrawn, after which sufficient concrete to fill two tube lengths is put into the interior of the tube. The pressure cap is then replaced, and air pressure is re-applied, the effect being to compress the concrete and to force the pile tube upwards. More concrete is then added and the process is repeated as often as is necessary. By carefully watching the gauge pressure and controlling the rise of the tube by the hand-operated relief valve, the forming of the pile is completed, each length of tube being unscrewed and removed as the joints become accessible. A clubbed foot, similar to that shown to the right hand of Fig. 1, is generally formed at the root of the pile, and, as the pile is gradually built up, an expansion in diameter takes place because of yielding of the surrounding soil, so that the average diameter of the pile is, we are informed, found to vary from 16in. to 24in., starting with a 12in. tube. As the top part of the pile is reached the working air pressure is reduced, and no pressure is put on the two last tubes, the concrete being simply tamped.

The process has been found, we are informed, to be particularly applicable to loose strata, because the concrete is blown out and fills up gaps in the manner already referred to and illustrated. The Belfast Customs House, to which we have already referred, is of especial interest in this connection, as in some instances the concrete piles, which were 35ft. to 40ft. in length, were inserted through the soft sleech and were formed with as little as 6ft. of headroom beneath the vaulting of the building. Although a similar method has been used on the Continent, the process described in this article, which is patented, is, we believe, the first of its kind to be carried out in London.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

Alfred Herbert, Ltd., of Coventry, asks us to announce that it has appointed H. W. Petrie, Ltd., Toronto, to be its Canadian agent.

The General Electric Company, Ltd., asks us to announce that the telegraphic address of its branch at Hull has been altered from "Switch" to "Electricity," Hull.

Hollings and Guest, Ltd., of Thimble Mill-lane, Birmingham, ask us to state that the name and address of their London representative are:—Mr. H. C. Amos, M.I. Mech. E., 22, Martin's-lane, Cannon-street, E.C. 4.

T. W. Ward, Ltd., of Sheffield, has recently acquired the Lactose factory in Tipperary, the Sanagen factory, also in Tipperary, and the Dundalk Ironworks, Co. Louth. It is understood that negotiations are in progress with a view to the re-starting of the three factories, but if they fail the works are to be dismantled.

The International Telephone and Telegraph Corporation, of Connaught House, 63, Aldwych, London, W.C. 2, asks us to announce that Mr. F. Gill has been elected a vice-president, that Mr. G. Deakin has been appointed first assistant chief engineer, that Mr. G. H. Nash has been appointed European chief engineer, that Mr. P. E. Erikson has been appointed assistant vice-president, and that Mr. E. S. Byng has been appointed European director of installation to that body.

Chilean Roads Construction Scheme.—The Chilean Legation in London has been advised by the respective Department of the Government that, in connection with the important project sanctioned recently for the construction of roads in various parts of the country, foreign contractors will be asked to tender for a considerable part of the work. The Government is at present preparing detailed plans, specifications, basis for tenders and all other particulars and information calculated to assist those interested in contracting for one or more of the sections for which tenders will be invited, and British firms interested should make early application for them to the Ministerio de Fomento, Santiago, Chile, through the Chilean Legation in London. The scheme provides for the construction of new roads and the improvement of existing ones in several parts of the country, some of the most important being:—(*a*) Province of Aconcagua, five roads comprising a total distance of 218 kiloms.; (*b*) Province of Santiago, seven roads comprising a total distance of 316 kiloms.; (*c*) Province of Colchagua, one road of 55 kiloms.; and (*d*) Province of Concepcion and Nuble one road of 80 kiloms.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Spiritless Market Conditions.

The Midland iron and steel market has received no fresh impetus as the result of last week's quarterly meeting, and business continues to flag. The readjustment of finished iron prices may lead eventually to increased orders, but there has been no rush to secure supplies at the new figure, and little if any more disposition to arrange forward contracts is manifest. Raw iron demand is about maintained, and little additional material is being put into stock, but that is about all that can be said for it. There are prospects of improving business in the steel department, but trade is fitful and, to some extent expensive, orders more often than not involving frequent roll changing at the mills. Trading conditions are such that increasing numbers of Midland iron and steel masters are urging the absolute necessity of measures of relief from foreign competition, and the conception that the industry should be afforded the protection of the Safeguarding of Industries Act in this area is making rapid progress.

Staffordshire Bar Prices.

The reduction of 10s. per ton on Staffordshire marked bars making the selling price £12 per ton, has left the impression that the new price will prove a rock-bottom figure. The market has been very firm lately, and large quantities have been called for for shipbuilding and engineering requirements, as well as for the manufacture of chains, cables, &c. It is remembered that during the past ten months no less than 50 shillings per ton has been taken off the price of this material, which at its peak after the war it was making as much as £33 10s. per ton. Business has of recent months been very steady, and the reduction in the basis rate should, it is thought, lead to larger business. This week there has been some readjustment of prices of medium class bars to bring them more within the hitherto regarded proportional relationship to superior bars. Special qualities of Crown bars of Staffordshire make which have been commanding £10 10s., are now quoted at £10. Lancashire prices have for some time past been in the neighbourhood of £10 to £10 5s., but some of the South Staffordshire firms require £10 5s. to £10 10s. A very superior Crown iron is quoted higher than that; on the other hand, Crown qualities made outside the Midland area are available at £9 5s. upwards. The demand for medium iron is rather slow, but makers of best quality bars are reported to have restarted on Monday with a fairly good reserve of orders. The outlook generally is said to show a little more promise. There is no great demand for nut and bolt and fencing iron, the reduction of quotations to £8 17s. 6d. having failed to attract customers. The tube works are busy, and are calling for heavy tonnages of iron strip. In an increasing number of quarters it is now asserted that wrought iron complying with the engineering tube standards is being more often specified for gas and water services. Iron strip has been reduced in price by 10s. per ton, being now offered at £11. Some really good orders should result.

Pig Iron.

Prospects have not improved in the pig iron department as the result of the quarterly meeting, and those smelters who anticipated the placing of forward contracts by users of foundry iron were disappointed. Midland furnacemen complain of the tardiness with which specifications are reaching them, and of the small tonnages involved. The Midland district, which is one of the principal centres of the light castings trade, has suffered acutely from the falling off in building activity. Foundries have been working much below capacity, and the progress of the season has not infused the new life into the industry which was expected. The change which has come over the forges in the past decade leaves furnacemen with small hope of any effective revitalisation from that quarter. With consumptive demand so poor it is not surprising that the stronger tone which the Cleveland pig iron market has recently developed has had no response in the Midlands. Furnacemen in this district have been struggling during the greater part of the quarter to maintain their position. They have not succeeded in averting a fall in values, but price deterioration has been kept within moderate limits. Quotations this week are approximately the same as they were a week ago. Northamptonshire No. 3 foundry was named £2 19s. to £3; forge, £2 13s. 6d.; Derbyshire foundry £3 4s. to £3 4s. 6d.; forge, £2 19s. per ton at furnaces. Consumers have not ceased to press for price concessions, and business is only given out when it is realised producers are adamant as regards price. Some Midland smelters this week express hope for a brisker demand from the foundries now that the way seems open for releasing building enterprise, which has been held up during the winter. They note with satisfaction that the number of furnaces in blast at the end of March was 150, a net increase of two since the beginning of the month, four furnaces having gone into blast and two having ceased operations.

Steel.

The steel department remains quiet, the market being void of any new development. Demand is sporadic, but nevertheless at last week's quarterly meeting the representatives of the steel firms the kingdom over reported favourably on the business situation. The demand for structural steel is fairly well maintained, and the mills recommencement after the holidays with a good reserve of orders. A good demand is reported for railway steel, especially in Sheffield mills. The Welsh mills are stated to be doing better than three months ago, largely because the rise in continental steel has brought back a good deal of the business in billets. Now that the foreign material costs £5 12s. 6d. delivered here, the Welsh mills very easily retain the home trade at £5 15s. Midland billet makers for the most part quote £3 for their products. Continental quotations are again firm, and merchants report difficulty in obtaining supplies of wire rods and carbon billets. There are no signs of giving way, and the demand is decidedly poor. The only sales which appear to be made are in respect of steel bars, which at £6 7s. 6d. undersell native material and meet with a fair demand from the stocking merchants. Staffordshire re-rollers, who a few months ago were practically using only foreign steel, are now taking British, and several steel works have excellent orders for billets and other descriptions of semi-finished material. Local mills are making a good deal of tube strip, and the unusual demand for large diameter tubes is keeping active one concern specialising on this product.

Galvanised Sheets.

Demand for galvanised sheets has again fallen off somewhat, especially as far as export business is concerned. Mills are now rolling again after the holiday break, but order books are getting low, and in order to attract business many makers this week offered supplies at a reduction of half-a-crown on last week's prices. Galvanised corrugated sheets of 24-gauge are down to £13 per ton f.o.b., though £13 2s. 6d. is quoted for small lots. The £13 5s. quotation is now rare. For black sheets the motor trade has lately been a good customer, and increasing demand from this quarter is anticipated.

Tin-plates.

Manufacturers of tin-plates who at last week's quarterly meeting endeavoured to get a premium on the basis of 18s., have this week continued their efforts with a certain amount of success. Many of them had, prior to last week's meeting, sold a considerable proportion of their output over the next month or two, and under the circumstances they declined to accept orders at late rates. Buyers were therefore forced to concede the required addition to price.

Scrap.

Scrap has become firmer, and merchants have increased their price for heavy steel scrap to £3 2s. 6d. delivered South Wales. The substantial Welsh demand encouraged Birmingham merchants to quote £3 5s., but they have found consumers unprepared to buy at this figure.

Trade's Upward Trend.

Although iron and steel masters cannot be said to be enamoured of the trend of trade in the basic industries, industrialists generally in this area express some gratification at the Board of Trade returns for March, and the first quarter of the year, both of which they contend confirm the impression that trade is slowly but surely improving. The feature affording most pleasure is the big increase in exports of articles wholly or mainly manufactured. The increase of over £1,000,000 in the exports of vehicles, including locomotives, ships and aircraft, and of £678,367 in machinery, is indeed pleasing. It is unfortunate that, on the other hand, the value of the exports of coal was down by £1,211,663, and the quantity by 709,249 tons on the previous March. The fall of £1,428,888 in the value of iron and steel imports is also welcome. The total quantity of iron and steel imported during the month was 271,526 tons, valued at £2,258,847, compared with 478,109 tons and £3,687,735 in the corresponding month of last year. For the year to date the quantity imported was 842,365 tons, valued at £6,815,791, compared with 1,476,986 tons and £11,383,796 in the preceding year.

Production Returns.

Local industrialists express qualified satisfaction with the returns of iron and steel production during the past month. Though the output in each case was greater than in the preceding month, it fell below that of the corresponding month last year. Production of pig iron amounted to 592,600 tons, compared with 550,800 tons in February and 671,800 tons in March, 1927. It is of interest to note that the production included 194,900 tons of hematite; 202,300 tons of basic; 151,800 tons of foundry; and 24,900 tons of forge pig iron. Output of steel ingots and castings in March amounted to 793,300 tons, compared with 764,400 tons in February and 949,600 tons in March last year.

Pithead Baths for Miners.

The new pithead baths for miners which have been installed by the Miners' Welfare Committee at Pooley Hall Colliery, near Polesworth, were formally opened by Viscount Chelmsford (chairman of the Miners' Welfare Committee) on Saturday. The new baths are the first of four sets of demonstration pithead equipments which the Central Miners' Welfare Committee has set out to provide in various parts of the United Kingdom, the other three, at present in course of erection, being at Broomside (Scotland), Treorchy (South Wales), and Mansforth (Durham). The essential difference in principle between the Pooley Hall Colliery design and that of existing installations in this country and on the Continent, is the complete separation of what are known as the clean and dirty sections of the buildings; in other words, after bathing and donning their ordinary clothes, miners are kept apart from those who come up in their dirty pitwear. The baths are of the shower type, and three different kinds of mixing valves are to be tested under ordinary working conditions. It is contended that there is a doubt at the moment as to how far the men will avail themselves of the facilities, and at the opening ceremony the miners' wives were asked to settle the issue by insisting that their husbands and sons should use the pithead baths.

Unemployment.

The effect of the Easter holidays upon unemployment in the Midlands is shown by the current returns. Compared with the week prior to the vacation, there was an increase in unemployment of 59,620, bringing the total up to 184,227. It is anticipated that a large proportion of the increase will be wiped off in the next return.

LANCASHIRE.

(From our own Correspondents.)

Manchester.

Exports of Textile Machinery.

A satisfactory position in the overseas branch of the trade in British textile machinery is disclosed by the Board of Trade returns for March. The value of the shipments during the month under review show a substantial increase over February, and one which fully discounts the fact that there were fewer working days in that month, whilst a slight improvement is also shown compared with January, itself a satisfactory period from the point of view of shipments of textile machinery from this country. Last month's exports were valued at £1,080,460, against £963,098 in the corresponding period of last year, and £885,070 in March, 1926, the respective tonnages in the three years being 11,057, 9933, and 9258. Exports of spinning and twisting machinery during March were 7823 tons, valued at £814,318, and of weaving machinery 2739 tons, valued at £194,156. After a rather lengthy spell of relative unimportance, shipments to the Russian market show a marked advance, and this is one of the outstanding features of the month's trade. The most important individual market was British India, shipments thence being valued at £216,834, followed by Russia with £140,917, Germany with £106,713, Japan with £84,635, France with £71,304, the Netherlands with £68,343, South America with £56,331, the United States with £45,661, Australia with £12,883, China with £12,503, and "other European countries" with an aggregate value of £228,426. The exports of textile machinery during the first three months of the present year amounted to 31,573 tons, valued at £3,055,235, compared with 26,988 tons and £2,666,717 in the corresponding period of last year and 28,171 tons and £2,691,569 in the first quarter of 1926, the present position thus comparing very favourably with either of the two preceding years.

A New Underground Scheme.

Mr. H. Mattinson, the general manager of the Manchester Corporation tramways, has elaborated a new scheme for an underground service of electric trains, with the object of relieving the city's traffic congestion problem. The scheme received preliminary consideration by the Tramways Committee on Tuesday this week, and it decided that it should be placed before the Underground Railways Committee and the Traffic Congestion Committee of the Corporation, with a view to a joint conference being held to discuss the whole scheme. Briefly, the proposal is to connect the principal railway stations in the city—Victoria, Exchange, London-road, and Central—with centres under Albert-square and Piccadilly. Mr. Mattinson's scheme must not be confused with that sponsored by the Manchester Underground Railways Committee, reference to which was made in this column on several occasions during the closing months of last year. A feature of the later scheme is the claim that the constructional work presents no great engineering difficulties and that the cost per mile would be very much less than that estimated by the Underground Railways Committee.

Commerce and the Air Port Proposal.

The board of directors of the Manchester Chamber of Commerce this week has given further consideration to the aerodrome proposal for Manchester, and defined its attitude to the question in the following proposal: The board is firmly of the opinion that Manchester will need an aerodrome in future years, and the sooner it is secured, the nearer it is likely to be to the centre of the city, which they feel is a consideration of great importance. At the present moment, however, the board feels that reductions in municipal rates are of such importance to the commercial community that they could not support suggestions that the Corporation should shoulder any financial responsibility which is not of pressing urgency. If those interested in aviation can show that arrangements can be made to secure a Manchester aerodrome without undue additions to the city's rates, the Chamber will give its approval and sympathy to their suggestions.

Non-ferrous Metals.

Apart from a somewhat surprising advance in the price of spelter, there have been no startling features about the non-ferrous metals market during the past week. Both copper and tin are fractionally cheaper on balance compared with a week ago, whilst lead continues to maintain the steady course that has characterised this section of the market during the past few weeks. So far as buying interest in the non-ferrous metals is concerned, the markets to some extent have been affected by holiday influences. The demand for copper has been on rather quiet lines, but although, as has been indicated, values of standard metal have given way a little, the undertone in this section of the market seems to be fairly healthy. Refined descriptions of the metal have held firm and show no change on balance. Activity in the tin market has been on a very moderate scale, and at one time weak selling had a serious effect on prices. In the early days of the present week, however, most of the lost ground was recovered, and the 10s. difference between current quotations and those of a week ago is not of great moment in the case of tin. A quiet trade has been put through in lead, and prices have been fully maintained. Although spelter has come in for only moderate attention from users, available supplies at the moment seem to be in very strong hands and prices quoted this week have been higher than at any time since the middle of February.

Pig Iron.

If one may judge from the amount of trade that has been done on the iron market here this week, seasonal influences are still at work. New orders have been comparatively few in number, and in the majority of cases have related to small parcels for delivery over the next month or so, fresh contract buying of any importance being very little in evidence. The principal makers,

however, are still able to report a fairly satisfactory flow of delivery instructions against contracts already held, and there is hope of an improvement in conditions regarding contract renewals before very long. In the meantime, values of foundry iron have been steadily maintained in all sections, with Midland brands quoted on a furnace basis of 64s. per ton, both for Staffordshire and Derbyshire makes, bringing the respective quotations for delivery Manchester or equal to 71s. 6d. to 72s. 3d. North-East Coast iron is quoted at 89s. per ton, Scottish at 87s. 6d., and hematite at 84s. 6d., also including delivery into this area in each case. In manufactured iron, Lancashire makers are unable to report any improvement in the relatively unsatisfactory conditions that have obtained here for some time. They do not, however, hold the view that further price reductions would be effective in attracting any more business, and are still quoting £10 per ton for Crown quality bars and £9 10s. for seconds.

Steel.

The demand for steel on this market is on a strictly early rolling basis, and, as contracts run out, the experience of sellers is that there is a marked tendency for support of this policy of buying to increase, rather than the reverse, current marketing conditions. Makers freely admit that this operates against users entering into any forward contracts of any weight. A quiet business is being done in boiler plates, quotations for which range from about £9 15s. per ton for basic plates to £10 for acid quality. Constructional materials are in moderate demand for early delivery and values are unchanged, joists and sections being quoted at £7 17s. 6d. per ton and general plates at £8 12s. 6d. Large steel bars are steady at £8 17s. 6d. per ton, with small re-rolled kinds at £7 12s. 6d., with considerably below this figure being accepted in the case of a decent order. There is only a quiet trade being done in imported steel products, but prices are rather steadier than of late, joists, for delivery to Lancashire works for cash against documents, being quoted at £5 15s. to £5 16s. per ton, Siemens plates at £7 14s., steel bars and angles at £6 5s., wire rods at £6 15s., billets at £5 6s., sheet bars at £5 7s. 6d., and bar iron at £6 2s. 6d.

Barrow-in-Furness.

Hematite.

There is still no change to report in the hematite pig iron trade in this district. The amount of business being done at the present time is not large, and the production is such that it means that a certain amount of iron must go into stock, and the amount going into stock is getting larger at the moment, in view of the fact that the steel departments are idle. At Barrow two furnaces are operating. The general business on home account is practically from hand to mouth, and as far as continental and American trade is concerned, there is little being done. Stocks exist at most of the works which are idle, and which have not produced for some months. The stocks are coming down, but it will be difficult to say how soon furnaces over at Ulverston or at Cumberland will be restarted. There is a more hopeful note, but whether there is any cause for it remains to be seen. The demand for iron ore is quiet, but only restricted buyings of either native or foreign exist at present. There is no change in the steel trade, which is dull. The rail, merchant and other departments at Barrow have not started yet, and at present it is impossible to say when they will be all going. It depends largely on orders which may be booked this month. There is a better trade in hoops than in other departments, and fairly substantial orders on overseas account have been booked. In the foundries there is a certain amount of activity.

SHEFFIELD.

(From our own Correspondent.)

Condition of the Steel Trade.

The position at works after the Easter holiday, which in some instances was protracted, shows little or no change, and there are no indications that the big revival in trade which has been predicted so long and frequently, is within measurable distance. During the stoppage there has been no accumulation of orders in the open-hearth section, and inquiries are few and far between, though it is pleasing to find that an open-hearth plant in Sheffield, which was closed a short time ago, has been restarted. Although there is a prospect of the recent expansion in the railway steel department being maintained, the amount of work coming in falls far below capacity, and firms are unable to keep their plants running full time. Closed down for several weeks owing to lack of suitable orders, a Siemens furnace at the works of J. H. Andrew and Co., Ltd., is being started up again. Builders of large vehicles for passengers and goods are continuing their orders for motor steel and parts, and it may be said that trade under that heading is developing, though here, again, there is still ample scope for extension. Figures showing the extent of production of Sheffield steel during the month of February are now available. The quantity produced in the Sheffield district amounted to 98,200 tons, which represents a decrease of 6300 on the previous month, whilst the output in February of last year was no less than 123,000 tons. In Lincolnshire the figures were 42,200 tons, compared with 38,000 tons in January and 45,400 tons in February last year. In addition to steel, Lincolnshire also produced 53,800 tons of pig iron, a drop of 2000 tons on the month, but up to the February, 1927, the production was standard.

The Tool Trade.

The wet summer last year played havoc with the garden tool trade, but this year there has already been a fairly large demand for garden tools of all kinds, and the outlook for further orders is distinctly promising. Indeed, the season promises to be above the average instead of below, as at one time seemed probable, though the demand on overseas account is not quite up to the average. There have been considerable reductions of prices during recent years. A further gratifying feature of the tool trade is the steadily increasing demand for twist drills and similar tools used in engineering. The saw trade and the demand for plantation tools, on the other hand, are not nearly so satisfactory, though at the same time there has been a somewhat better demand for saws of late. It is understood that some half-dozen firms will participate in the Admiralty contract for a year's supply of files and rasps, amounting to about 25,000 dozens, which has been given out. Leaving this contract out of consideration, the file trade can scarcely be said to be run on a remunerative basis, for although orders are fairly plentiful, there is much complaint on the score of prices, whilst the volume of work is much below output capacity, the absence of Russian trade on the former scale contributing in large measure to this condition. Although there is no competition in the home market, prices have dropped to a level which is practically tantamount to executing orders for the sake of keeping departments open. Nowadays files are being sold almost at pre-war prices, although material and wages are much higher. The dilution of skilled labour and improved practice have enabled some reduction in costs to be effected, and another factor is that more women are employed on the cutting of small files than formerly.

A New Cutting Alloy.

The placing on the market of a new cutting alloy, which bears the name of "Osborn's S.O.B.V. cutting alloy," is a matter of interest in engineering circles. During the past eighteen months Samuel Osborn and Co., Ltd., have been conducting experiments with a view further to improve their famous high-speed steels, and the advantages claimed for this, their latest product, are that it can be heat-treated in a similar way to high-speed steel; it is not brittle, but is anneable and forgeable; and that it will cut harder materials at higher speed and heavier cuts than anything hitherto produced. Tests have been made, both in their Sheffield shops, where, of necessity, the period of testing was short, and in other shops, under normal engineering conditions, where the trials were of a more lengthy nature. In certain large shops the output of brake-hardened tires has been quadrupled, this being under conditions which were not too good and with native labour. In their own works Messrs. Osborn are machining manganese steel in both the forged state and in castings with Osborn's "S.O.B.V. cutting alloy." They are also drilling holes in manganese steel plates and rails with drills made from the same alloy. Results show that the alloy is far in advance of any cutting material which the company has hitherto produced.

Sheffield to Supply Army Razor Blades.

Despite the quiet Easter trade, especially in the best quality goods, there is still a considerable output of cutlery and plate, whilst the trade in safety razor blades is being maintained at the recent improved level. In this connection, it is of special interest that the British Army is to shave with British blades once more. For the new supply of safety razor blades, an enormous number of which are required annually by the Army, only British firms have been invited to tender. Twenty safety razor blade manufacturers have received tender forms, and the majority of these makers is established in Sheffield. It will be recalled that British manufacturers protested to the War Office when an American firm alone was invited to submit tenders for the Army supply some time ago, and that after negotiations between the War Office and the Sheffield Cutlers' Company, specified standards for the new supply of blades were determined. The Cutlers' Company supplied the War Office with the names of manufacturers in Sheffield, and these firms have been invited to tender for the new requirements.

Rotherham Firm's Possible Move.

The well-known steel firm of John Baker and Co., Rotherham, which has two establishments in that town and one at Kilnhurst, is considering the advisability of concentrating its energies at Kilnhurst, though it may be two years or more before any change is made. It is felt that concentration at Kilnhurst would tend to bring down production costs.

Leadmill Bridge at Hathersage.

It has not yet been possible to ascertain the cost of the work of repairing the new Leadmill Bridge at Hathersage, in the Derbyshire County Council's area. This structure, it will be recalled, was badly damaged by floods some time ago at a time when it was approaching completion. The Ministry of Transport engineer is in agreement with the County Surveyor that the large pier—formerly the bridge abutment—should be reduced in width, as it would increase the waterway of the flood arch. The sum of £7000 has been included in the estimate to cover the whole work of repair, and the total expenditure will be eligible for grant.

Low Prices for Tramcar Bodies.

A good deal of interest is being taken in Sheffield and elsewhere in the action of the City Council in allocating a contract for the building of twenty-five tramcar bodies to the South Shields firm of W. and E. Hill, Ltd., at the very low price of £1190 per car. At the Council meeting the chairman of the Tramways Committee stated that Messrs. Hill have never built tramcars before. Sheffield itself has a well-known firm of tramcar builders in Craven's Railway Carriage and Wagon Company, Ltd., and Mr. W. H. Anderson, the managing director of that company, has made some interesting comments on the situation, and given a good deal of information. He says that Messrs. Hill must, according to their figures, be losing money on every car. Messrs. Craven themselves quoted for these twenty-five cars £1620 each, and the other firms who tendered were: Brush Electrical Engineering Company, Ltd., Loughborough, £1648 each; English Electric Company, Ltd., Preston, £1655; Hurst, Nelson and Co., Ltd., Motherwell, £1665. Mr. Anderson states that the last tramcar bodies, which were of a much cheaper type, cost the Sheffield Corporation £1390, and, as these showed 5 per cent. profit their actual cost was £1320. He also gives the following particulars with regard to orders placed during the last two years for car bodies, all of a much cheaper type than those required for Sheffield:—Cardiff, thirty bodies at £1503 14s. each; West Ham, ten at £1520; Croydon, ten at £1580; East Ham, ten at £1587; Birmingham, fifty at £1390; Glasgow, fifty at £1221. He points out that the last-named figure was an average price. Messrs. R. Y. Pickering and Co., railway carriage and wagon builders, of Wishaw, submitted a very low tender, but, as they had not previously built tramcars, the Glasgow Council decided to divide the work, with the result that Pickerings received an order for ten bodies at £1060; Motherwell, thirty at £1245; and the Brush Electrical Company, ten at £1310. It suggested that it might have been wisdom on the part of Sheffield Corporation to adopt a similar plan.

Order "Partly Promised."

"The price of £1620, which we quoted," says Mr. Anderson, "was most carefully estimated, and includes only a very narrow margin of profit." He repudiates any suggestion that the price was an enormous one, arranged by an imaginary "ring" of tramcar builders, and says it was a purely competitive price. "As a matter of fact," he continues, "the No. 1 car which we recently supplied to the Corporation, and which is the sample for the twenty-five at present in question, actually cost £2120, and a dead loss was incurred of no less than £591. In view of this, can anyone say that our price of £1620 is unreasonable? The cost of preparing drawings—about £150—was not taken into consideration, as we had partly been promised the order for twenty-five cars, and we hoped to recoup ourselves on these." Mr. Anderson agrees that if the cars to be built by the South Shields firm are of the quality expected, then the Sheffield Corporation has made a very good bargin in the interests of the ratepayers, but says it seems to him that the firm is losing money on every car for the purpose of creating a new industry in South Shields. He also points out that the loss of the contract is a serious matter for the Sheffield firm. It would have provided employment for 126 men for twenty weeks, but now 75 per cent. of those men will have to be discharged, as the carriage work the firm has on hand is coming to an end, and there is nothing else in view.

NORTH OF ENGLAND.

(From our own Correspondent.)

Shipbuilding Activity.

Five vessels were launched in the river Tyne this week, the builders being Palmer's Shipbuilding and Iron Company, Ltd., Sir W. G. Armstrong, Whitworth and Co., Ltd., and Swan, Hunter, Wigham Richardson and Co., Ltd. Recently a record was made on the Tyne, when seven vessels were launched in one week. Output is still rapid, and the outlook for new tonnage to take the place of vessels launched is anything but promising. There are a few inquiries circulating, but shipbuilders and brokers are taking a gloomy view of the future. Within the past few weeks scarcely half-a-dozen new orders have been placed on the North-East Coast, which is much below what is required to keep the yards going after the next two or three months, when some of the firms will practically be through the work they now have in hand. Last year and this year the Tyne has set up some good records for rapid output, in connection with which mention might be made of the Palmer Company's performance in delivering an oil tanker in about sixty-five days. The vessel was launched in fifty-two days from the turning of the first frame, and the patterns of the engines had all to be made. Swan, Hunter and Wigham Richardson's, in launching seven Canadian Lake steamers recently in practically two months, also accomplished an outstanding performance. The Tyne still holds the record for rapid completion after a vessel had been placed in the water. This was done by the Northumberland Shipbuilding Company, Howdon, and the North-Eastern Marine Engineering Company, Wallsend, in November, 1908. In two and a half days from the time of launching a 9000-tons vessel her engines were installed, successful trials were carried out, and the ship handed over to her owners.

Cleveland Iron Trade.

The outlook for the near future is causing some uneasiness, as the volume of new business passing is insufficient to maintain works activity as orders on hand run out. Prospects are regarded as somewhat less encouraging than they have been, but some expansion of demand is still looked for. The labour troubles in Germany are attracting considerable attention. The situation looks serious, and stoppage at German iron and steel works and collieries would no doubt have some beneficial effect upon this district, but the prevailing opinion here is that cessation of operations is unlikely to be of sufficiently long duration to avert extensive orders to this country. Production of Cleveland pig iron is promptly absorbed, and to meet current needs against running contracts, the already very low stocks are being further reduced. Ironmasters continue to use the bulk of the make at their own foundries and steelworks, but deliveries to home firms who have to buy in the open market and to consumers in Scotland are on quite a good scale. Prices are steadily maintained, No. 1 Cleveland foundry iron being 68s. 6d.; No. 3 G.M.B., 66s.; No. 4 foundry, 65s.; and No. 4 forge, 64s. 6d.

East Coast Hematite.

Though the output of East Coast hematite pig iron continues in excess of requirements, makers are taking a slightly firmer stand. Prices are not advanced and are on an altogether unremunerative scale, but the tendency is upwards, consequent upon just a little improvement in demand. The nominal basis of quotations remains at 70s. for mixed numbers, but consumers claim they can satisfy their needs on lower terms. On the other hand, named brands are stated to have realised rather more than equal to the recognised market rate for mixed numbers.

The tonnage disposed of, however, falls considerably short of absorbing the output, and stocks continue to accumulate.

Ironmaking Materials.

The situation in the foreign ore trade is attracting a little more notice, but business is still very quiet. German consumers are understood to have bought so heavily as to threaten a shortage of supply for this country, but consumers in this district are as disinclined as ever to negotiate for extensive forward deliveries. Best Rubio ore keeps at 22s. 6d. per ton c.i.f. Tees. Durham blast-furnace coke is in moderate request. Good average qualities are put at 18s. per ton delivered at North-East Coast works.

Manufactured Iron and Steel.

In certain departments of the manufactured iron and steel trade, contracts on hand are being rapidly executed, and orders coming forward are not on a sufficient scale to ensure continuation of the present activity at the works. Prices, however, are well maintained.

The Coal Trade.

Although new business for prompt delivery is not offered in any special volume, the general position of the Northern coal trade is quite favourable for the fitters. In all descriptions bookings to the end of April are on a very substantial scale, and only limited surplus quantities are available. Prices rule on steady lines, and they may conceivably harden in view of the German mining situation, although it is probable that the influence from that direction will not amount to much. Under the arbitration proceedings, the working hours are unaltered and the men have got an advance of 8 per cent., which will come into force next month. The effect may be to make the competition of British coal against German coal a little more advantageous. The award, however, does not seem to have met with acceptance by either the men or the masters. In view of the uncertain German situation, shippers in this area with early commitments have not hesitated to book. This feeling has caused the present month's normal output to be earmarked, and for any qualities firm prices are asked. For next month business is scarce, as whilst there is a substantial sounding of the market, operators are not inclined to commit themselves. Most of the best steam coal collieries in Northumberland have considerable orders to go on with this month. Prices rule from 13s. 4½d. to 13s. 6d. for best qualities, and up to 12s. for second sorts. Durham gas coals are also in active request for prompt shipment, and prices are well maintained. Very little forward business is heard of, but this week 10,000 tons of good second class fuel have been sold for shipment to Sweden at 18s. 5½d. per ton c.i.f., delivery to be from November to January. Coking coals are firm, and sellers ask 14s. for bests, and good classes are changing hands at 13s. 9d. Bunkers are offering at 13s. 3d. to 13s. 6d. for ordinaries and 14s. to 15s. for superior grades. There is a good supply of gas coke offering, and, in view of keen competition from other centres of supply, prices are slightly easier. Patent oven cokes are plentiful, but steady in tone; good brands, 17s. to 18s.; special makes, 23s. to 25s.; and beehive coke, 24s. to 27s.

SCOTLAND.

(From our own Correspondent.)

Inactive Markets.

CONDITIONS in the steel, iron and coal markets are unchanged. Generally speaking, demands are very restricted, and inquiries do not indicate any prospect of an early improvement.

Steel.

The demand for heavy steel continues on recent lines. As a rule, the amounts specified are small, entailing frequent changing of rolls at the mills. Outputs of plates and sections are comparatively steady, but are not increasing, and difficulty is experienced in keeping plants in anything like regular employment. Prices are unchanged. Demands for shipbuilding material and also for structural work are somewhat disappointing.

Steel Sheets.

Some sheet mills have been a shade busier during the past few days, but there is still no sign of a lasting improvement in turnover. Heavy sheets are comparatively slow, and the demand is chiefly confined to the lighter varieties of black sheets and galvanised sheets. Prices are steady.

Iron.

Bar iron makers are meeting with keen opposition from steel makers and Belgian iron, and though export prices are in some cases severely cut, makers are securing very little fresh business. The same may be said of the re-rolled steel section of the industry. Re-rolled steel bars are quoted £7 15s. per ton home and about £7 per ton export.

Pig Iron.

The actual turnover in Scottish pig iron is comparatively small, and prices are only maintained, owing to dearer ore and a lessening of imports from the Continent and other sources. Fair quantities of Cleveland pig iron are being sold in this district. Shipments of Scottish pig iron during the past week amounted to 413 tons. Prices are unchanged.

Exports and Imports.

During the past week some 14,000 tons of iron ore were discharged at Glasgow, and other arrivals included 1000 tons of pig iron from India, 1200 tons of iron and steel products from the Continent, and 700 tons of ship plates also from the Continent. Shipments of iron and steel products totalled 6300 tons, and were dispatched to Australia, New Zealand, China, India, South America and South Africa.

Scrap.

Business in scrap material is comparatively steady, most qualities finding a fairly ready outlet. Prices are maintained at 65s. per ton heavy steel, and 62s. 6d. per ton cast iron scrap.

Coal.

Conditions in the coal markets are unchanged. The scheme for the limitation of output is not yet in full operation, but the effect is already apparent, supplies of fuel being less plentiful and prices firmer, with the possible exception of treble and double nuts in the Lothians and Fifeshire. With the position so uncertain, exporters are not taking any risks, and the shipping turnover is exceedingly small. Prompt orders are few and far between, and forward business is almost discontinued. Aggregate shipments amounted to 219,428 tons, against 241,632 tons in the preceding week and 291,408 tons in the same week last year. Home demands are declining as the season advances.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

THE Easter holidays naturally had a prejudicial effect upon shipments of coal from this district, as will be seen from the total of 299,926 tons for the week ending the 13th inst., which compared with 318,597 tons for the preceding week. Still, considering that the week ending the 13th inst. comprised only three working days, the quantity returned is fairly good, but it is, of course, unlikely that the aggregate figures for the current month will prove as satisfactory as those for March. Considering the general quietness of business, it is somewhat surprising that the loading position continues to be as good as it is. At the end of last week there were only thirteen idle tipping appliances at the various docks, and seven steamers were actually waiting to get into berth; but, unfortunately, the very bad weather which prevailed during the week-end prevented many steamers from arriving as expected. The result was that on Monday the number of idle loading appliances had increased to twenty-two. It is quite possible that the loading position may become rather worse later on, as the volume of chartering operations during the past fortnight has been well below the average. At the same time, a fair number of orders are held by merchants, who are finding it not quite as easy as a few weeks ago to secure the tonnage which they require. There is no doubt that the very poor rates of freight which have prevailed now for some time have had the effect of compelling many owners to lay up their ships temporarily, and their action is now making its influence felt on the market. Since writing a week ago, very little new business of importance has come on the market. The Italian shipping company, the Navagazione Generale Italiana has purchased about 60,000 tons of best Admiralty large coals for delivery from May to September, and the Greek State Railways are in the market for a couple of cargoes of large steam coals of 5000 tons each, for delivery within about a month from the time that prices have to be submitted, viz., the 25th inst. There is also an inquiry on Irish railway account for 40,000 tons of large coal for delivery over twelve months, but the belief is that this order will go to Scotland. A watchful eye is being kept upon the position in the Ruhr in view of the wages dispute between the mineowners and the workmen. Any trouble in that district would, of course, have a strengthening effect upon South Wales coals. The Government arbitrator has awarded the Ruhr miners an increase of 8 per cent. as from May 1st, and reduced the working hours of all classes of surface workers, but the underground shift remains unaltered at eight hours. It appears that both the employers and the miners are dissatisfied with the award, but the probability is that the Government will declare the award binding, as it has statutory power to do. Germany profited immensely from the strike troubles in the coalfields of this country in 1926, but it is very unlikely that a strike will on this occasion be allowed, and will thus permit of the tables being turned on them to the advantage of the industry of this country.

Coal Stabilisation Scheme.

The position to date is that no progress has apparently been made towards a solution of the difficulties with which the Committee has for a long time been faced, and therefore there is still no official statement as to when the scheme as a whole is to come into operation. There was a meeting of the Executive Committee the day before Good Friday, when the position was fully discussed, but quite apart from the question of the classification of coals and the minima prices, it is understood that the acceptance of the scheme by a number of undertakings continues to be conditional, which, of course, makes it difficult to bring about agreement.

Tin-plate Trade.

Quite a number of tin-plate works have of late been idle, partly on account of the Easter holidays and to the operation of the scheme for the stabilisation of the industry and the equitable distribution of work. So far as the Llanelly district is concerned, there was almost a general resumption of work on Monday last, on which date also a new six-mill sheet plant, erected by the Llanelly Steel Company, was opened. This company, it will be recalled, spent not long ago thousands of pounds in laying down a new bar mill on the American Morgan continuous system at its steel works, where there are twelve furnaces. The sheet mills, which are equipped with cold rolling and galvanising departments, are situated on a site adjoining the Llanelly Steel Works, and embody the latest developments. They provide for a greatly increased output, as compared with that generally in use, and it is stated that employment will be found for at least 300 men.

Current Business.

The tone of the steam coal market continues to be quiet, and so far as values are concerned there is no variation practically from those prevailing before the holidays. If anything, more orders are held by merchants, but the general volume of operations is quite insufficient to impart better conditions to the trade as a whole. Some undertakings producing the superior grades are fairly well placed, but this is not the situation of many collieries producing the lower qualities. Small coals are steady on account of the restricted production and the stoppages which have taken place in the coalfield. In the anthracite section the conditions are steadier and supplies are moving off more freely.

LAUNCHES AND TRIAL TRIPS.

YARRAVILLE, oil tanker; built by Messrs. Lithgows, of Port-Glasgow, to the order of Vacuum Oil Company, Ltd.; dimensions, 460ft. by 62ft. 6in. by 36ft. 6in.; to carry oil in bulk. Engines, inverted direct-acting triple-expansion, pressure 220 lb. per square inch; constructed by David Rowan and Co., Ltd., Glasgow; a mean speed of 12 knots was attained on trial trip, March 30th.

LIVINGSTON, steamship; built by Sir W. G. Armstrong, Whitworth and Co., Ltd., to the order of Mathews Steamship Company, Ltd.; dimensions, 259ft. 6in. by 43ft. 6in. by 21ft. 6in.; to carry 2350 tons on a 14ft. draught. Engines, triple-expansion, 17in., 28in., 46in. by 36in. stroke, pressure 200 lb. per square inch; constructed by the builders; launch, April 3rd.

BRITISH PLUCK, steel screw motor ship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of British Tanker Company, Ltd., London; dimensions, 240ft. by 32½ft.; to carry 1000 tons deadweight on a draught of 12ft. Engines, set of Atlas Polar Diesel engines with six cylinders; constructed by the builders; launch, April 4th.

BRITISH DOMINION, oil tanker motor ship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of British Tanker Company, Ltd.; dimensions, 454ft. by 57ft.; to carry 10,200 tons deadweight on a draught of about 26ft. 8in. Engines, set of single-screw Doxford-Diesel engines; a speed of 11½ knots was attained on trial trip, April 4th.

TIA JUANA, shallow-draught oil tanker; built by Harland and Wolff, Ltd., to the order of Lago Shipping Company, Ltd.; dimensions, 315ft. by 50ft.; 2360 gross tonnage. Engines, twin-screw triple-expansion, pressure 180 lb. per square inch; constructed by the builders; trial trip, April 4th.

TROISDOC, steamship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Paterson Steamships, Ltd., Fort William, Ontario, Canada; dimensions, 253ft. long. Engines, inverted marine type; constructed by the builders; trial trip, April 5th.

ALNWICK, single-screw steamer; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Tyne-Tees Steam Shipping Company, Ltd.; dimensions, 265ft. by 38ft. 9in.; to carry 1400 tons deadweight. Engines, triple-expansion; constructed by the builders; a speed of over 14½ knots was attained on trial trip recently.

CONTRACTS.

ALLOY WELDING PROCESSES, Ltd., of 14–16, Church-street, Islington, London, N. 1, received the order for the electric arc welding equipment for the new floating dock for Singapore. The machine consisted of a central motor driving two "A.W.P." generators of the firm's self-stabilising, drooping characteristic type.

THE M.A.N. COMPANY, of Nuremburg, has received an order to supply the main engine for a single-screw cargo motor vessel which is to be built by Urago Dock Company for the Yamashita Kisen Kaisha, Tokio. The engine is to develop 3200 B.H.P. at 115 r.p.m. Three auxiliary engines, each developing 175 B.H.P. in three cylinders, are also to be supplied.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., of Rugby, has received orders for traction equipment from the Manchester Corporation and from the Sheffield Corporation. That for Manchester is for thirty traction motors and fifty controllers, while that from Sheffield is for 100 controllers and twenty-five lightning arresters. The same firm has also received an order from the London and North-Eastern Railway for a twelve months' supply of Mazda electric lamps.

THE SKODA WORKS, Ltd., of Prague, Czechoslovakia, has recently sold to the Chapei Electricity and Waterworks Company, Shanghai, an extra-high pressure turbo-generating plant comprising three boilers, with superheaters and economisers, the boilers to work at a pressure of 40 atm. with steam at 425 deg. Cent.; an evaporator and pumps for supplying the feed water; two two-casing steam turbines for 35 atm. steam pressure and 400 deg. Cent. steam temperature, direct coupled to two turbo-generators, each of 12,500 kW capacity, 6600 volts at 3000 r.p.m.; one travelling crane of 40 tons capacity; a back-pressure auxiliary turbine of 500 kW, switchgear, transformers, &c.

THE JUNIOR INSTITUTION OF ENGINEERS.—Mr. A. P. Morris, in his lecture on "Calculating Apparatus and Diagrams for Engineers," on April 13th, kept well away from mathematics, for, he said, there was a vast difference between mathematics and calculation. The former demanded imagination and the latter demanded none. Calculation was mechanical and that was why a machine could do the work. The human brain could be trained as a calculating machine, which would work smoothly until it paused to think, and then a jam would occur; it had to work unconsciously. In the seventeenth century Pascal devised a calculating machine which was afterwards improved upon by other inventors and was still sold in one of its forms in Germany. Modern attempts to revive Napier's bones and rods dated as late as 1905. A machine made by Leibnitz in 1694 involved what was known as Leibnitz's wheel—a device which had been used extensively in later machines. Mr. Morris demonstrated two modern types of machines, one of which made use of wheels with teeth which could be varied in number by a perfect piece of mechanism, the other being of the type in which the action was produced by depression of keys bearing on a lever at different distances from its pivot. Neither of these mechanisms was new in principle, said Mr. Morris; the trouble was that it took a genius to devise a new mechanism and then a host of geniuses to make it fool-proof. Modern machines were guarded so that if wrongly manipulated they either refused to work or rang a bell. Of the slide rule, Mr. Morris said that its advantages were that it was usually sufficiently accurate and that it fitted the pocket in more senses than one.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
(1) Native	19/- to 21/-
(1) Spanish	19/- to 21/-
(1) N. African	19/- to 21/-
N.E. Coast—	
Native	18/- to 21/-
Foreign (c.i.f.)	22/6

PIG IRON.

	Home. £ s. d	Export. £ s. d.
(2) Scotland—		
Hematite	3 14 0	—
No. 1 Foundry	3 15 0 to 3 16 0	—
No. 3 Foundry	3 10 0 to 3 11 0	—
N.E. Coast—		
Hematite Mixed Nos.	3 10 0	3 10 0
No. 1	3 10 6	3 10 6
Cleveland—		
No. 1	3 8 6	3 8 6
Silicious Iron	3 8 6	3 8 6
No. 3 G.M.B.	3 6 0	3 6 0
No. 4 Foundry	3 5 0	3 5 0
No. 4 Forge	3 4 6	3 4 6
Mottled	3 4 0	3 4 0
White	3 4 0	3 4 0
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	—	—
,, ,, Foundry	3 3 6	—
(3) Northampton—		
Foundry No. 3	2 19 0 to 3 0 0	—
Forge	2 13 6	—
(3) Derbyshire—		
No. 3 Foundry	3 4 0 to 3 4 6	—
Forge	2 19 0	—
(3) Lincolnshire—		
No. 3 Foundry	3 3 0	—
No. 4 Forge	3 2 6	—
Basic	3 2 6	—
(4) N.W. Coast— N. Lancs. and Cum.— Hematite Mixed Nos.	4 2 0 (a) / 4 5 0 (b) / 4 8 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d	Export. £ s. d.
Scotland—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. Coast—		
Iron Rivets	11 5 0	—
Common Bars	10 5 0	—
Best Bars	10 15 0	—
Lancs.—		
Crown Bars	10 0 0	—
Second Quality Bars	9 10 0	—
Hoops	13 0 0	—
S. Yorks.—		
Crown Bars	10 10 0	—
Best Bars	11 0 0	—
Hoops	12 0 0	—
Midlands—		
Crown Bars	9 5 0 to 10 0 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	8 17 6 to 9 0 0	—
Gas Tube Strip	11 0 0	—

STEEL. (d)

	(6) Home. £ s. d	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	10 10 0	10 10 0
Ship Plates, ½in. and up	8 7 6	7 12 6
Sections	7 17 6	7 2 6
Steel Sheets, ¼in.	8 12 6	8 10 0
Sheets (Gal. Cor. 24 B.G.)	13 7 6	13 5 0

STEEL (*continued*).

	Home. £ s. d	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 15 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	7 12 6	—
Soft Billets	6 15 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 5 0	—
Light Rails	8 10 0 to 8 15 0	—
Billets	7 10 0 to 10 0 0	—
Manchester—		
Bars (Round)	8 17 6	—
,, (Small Round)	7 12 6	—
Hoops (Baling)	10 5 0	10 0 0
,, (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6	—
,, (Lancs. Boiler)	10 0 0	—
Sheffield—		
Siemens Acid Billets	10 0 0	—
Hard Basic	7 2 6 to 7 12 6	—
Intermediate Basic	7 0 0	—
Soft Basic	6 5 0	—
Hoops	9 10 0 to 10 10 0	—
Soft Wire Rods	7 10 0	—
Midlands—		
Small Rolled Bars	7 5 0 to 8 0 0	—
Billets and Sheet Bars	5 15 0 to 6 0 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	—
Galv. Sheets, f.o.b. L'pool	13 0 0 to 13 2 6	—
Angles	7 17 6	—
Joists	7 17 6	—
Tees	8 17 6	—
Bridge and Tank Plates	8 12 6	—
Boiler Plates	11 0 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	18/- to 18/3
Block Tin (cash)	234 17 6
,, (three months)	235 10 0
Copper (cash)	61 11 3
,, (three months)	61 12 6
Spanish Lead (cash)	20 1 3
,, (three months)	20 8 9
Spelter (cash)	25 10 0
,, (three months)	25 7 6
Manchester—	
Copper, Best Selected Ingots	65 15 0
,, Electrolytic	67 5 0
,, Strong Sheets	92 0 0
,, Tubes (Basis Price), lb.	0 1 1
Brass Tubes (Basis Price), lb.	0 1 0
,, Condenser, lb.	0 1 2
Lead, English	21 12 6
,, Foreign	20 10 0
Spelter	24 17 6
Aluminium (per ton)	£107

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/7½ per lb.	
Ferro Tungsten	1/3 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22 15 0	7/6
,, ,, 6 p.c. to 8 p.c. ,,	£22 7 6	7/-
,, ,, 8 p.c. to 10 p.c. ,,	£22 5 0	6/-
,, ,, Specially refined		
,, ,, Max. 2 p.c. carbon	£35 0 0	12/-
,, ,, ,, 1 p.c. carbon	£40 10 0	15/-
,, ,, ,, 0·70 p.c. carbon	£47 0 0	17/-
,, ,, ,, carbon free	1/2 per lb.	
Metallic Chromium	2/11 per lb.	
Ferro Manganese (per ton)	£13 10 0 for home; £13 10 0 for export	
,, Silicon, 45 p.c. to 50 p.c.	£12 17 6 scale 5/- per unit	
,, ,, 75 p.c.	£20 10 0 scale 6/- per unit	
,, Vanadium	14/3 per lb.	
,, Molybdenum	4/8 per lb.	
,, Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£170 to £175	
Ferro-Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

(Prices not stable.)

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	13/9
,, ,, Ell	14/6
,, ,, Splint	16/3 to 17/-
,, ,, Trebles	13/3
,, ,, Doubles	12/3
,, ,, Singles	11/3
Ayrshire—	
(f.o.b. Ports)—Steam	13/-
,, ,, Jewel	15/6
,, ,, Trebles	12/9
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	10/6 to 12/9
Screened Navigation	18/-
Trebles	12/9
Doubles	11/6 to 12/-
Singles	11/6
Lothians—	
(f.o.b. Leith)—Best Steam	11/6 to 12/-
Secondary Steam	11/6
Trebles	12/9
Doubles	12/-
Singles	11/3

ENGLAND.

(8) N.W. Coast—	
Steams	24/- to 25/-
Household	37/6 to 50/-
Coke	22/6 to 23/6
Northumberland—	
Best Steams	13/6 to 14/-
Second Steams	11/9 to 12/-
Steam Smalls	9/- to 9/6
Unscreened	11/9 to 12/-
Household	21/- to 27/-
Durham—	
Best Gas	15/- to 15/3
Second	13/3 to 13/9
Household	21/- to 27/-
Foundry Coke	17/6 to 18/-
Sheffield— Inland.	
Best Hand-picked Branch	27/6 to 29/6 —
Derbyshire Best Bright House	20/6 to 21/6 —
Best House Coal	19/- to 20/6 —
Screened House Coal	16/- to 17/6 —
,, ,, Nuts	15/- to 16/- —
Yorkshire Hards	15/- to 16/- —
Derbyshire Hards	14/6 to 15/6 —
Rough Slacks	8/6 to 9/6 —
Nutty Slacks	6/- to 7/- —
Smalls	3/- to 4/6 —
Blast-furnace Coke (Inland)	13/- at ovens —
Furnace and Foundry Coke (Export), f.o.b.	16/9 to 17/6

(9) SOUTH WALES.

Cardiff— Steam Coals:	
Best Smokeless Large	19/3 to 19/6
Second Smokeless Large	18/6 to 19/-
Best Dry Large	18/- to 18/6
Ordinary Dry Large	17/6 to 18/-
Best Black Vein Large	17/- to 17/3
Western Valley Large	16/6 to 16/9
Best Eastern Valley Large	16/6 to 17/-
Ordinary Eastern Valley Large	16/- to 16/3
Best Steam Smalls	12/6 to 13/-
Ordinary Smalls	11/- to 12/6
Washed Nuts	18/- to 23/-
No. 3 Rhondda Large	19/6 to 20/-
,, ,, Smalls	14/- to 14/9
No. 2 ,, Large	16/- to 16/6
,, ,, Through	14/6 to 15/6
,, ,, Smalls	12/6 to 13/6
Foundry Coke (export)	30/- to 37/6
Furnace Coke (export)	27/6 to 30/-
Patent Fuel	21/6 to 23/-
Pitwood (ex ship)	27/- to 27/3
Swansea— Anthracite Coals:	
Best Big Vein Large	30/- to 34/-
Seconds	24/6 to 27/6
Red Vein	20/6 to 25/-
Machine-made Cobbles	39/- to 42/-
Nuts	37/6 to 42/6
Beans	23/- to 27/-
Peas	17/- to 18/-
Breaker Duff	8/- to 8/6
Rubbly Culm	9/9 to 10/3
Steam Coals:	
Large	17/6 to 18/6
Seconds	16/- to 17/-
Smalls	9/9 to 11/-
Cargo Through	15/- to 16/-

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (a) Delivered Glasgow. (b) Delivered Sheffiel

(c) Delivered Birmingham. (d) Rebate 12/6 joists and 10/- all other materials if home consumers confine purchases solely to British products.

French Engineering Notes.

(From our Correspondent in Paris.)

Public Works.

THE distribution of orders by the railway companies and the State is mainly responsible for a little more activity in the engineering industries, and the outlook is regarded as more satisfactory in view of the programme of public works which it is proposed to start upon during the present year with the aid of material obtained from Germany on account of reparations. Amongst the works to be put in hand are improvements to the ports of Cherbourg, Bordeaux, Havre and Dunkirk. Some important contracts have already been given out, including one for the construction of wharves and the equipment of elevating plant at Havre. Following upon the completion of those works similar improvements and extensions will be carried out at Nantes, Marseilles and La Rochelle. There will be considerable activity in railway electrification, and a beginning will be made with the equipment of goods trains with continuous brakes, the final details of which have now been settled between the Government and the railway companies. It is unknown yet whether the Germans will be allowed to supply their own brakes or whether they will be required to manufacture the new Westinghouse brake for the French railway companies. All the accessory parts will be made in the country. Contracts have already been given out in Germany for the construction of the Verdon barrage and power station, and that country will also participate in the construction of the power stations at La Cure and on the Rhine, and eventually in the equipment of power stations on La Truyère and the Dordogne. It will also supply machinery and plant for private works, such as engineering works, paper factories and the like. At the same time, the Colonies are requiring considerable quantities of railway and other material, and the activity suggested by these proposed undertakings, with the aid of German reparations, is imparting a decidedly confident tone to industry generally.

Railway Improvements.

In their annual reports the railway companies give a full account of the works they have carried out during the past year, and the Orleans Company refers more particularly to the reconstruction of the permanent way with heavier ballast, new rails and manganese steel points. The number of sleepers is being increased from 21 to 27 per length of 16·5 m. of rail. It is noted that, on the electrified lines, the total consumption of energy during the year was 109 million kilowatt-hours, 70 per cent. of which was supplied by the Eguzon hydro-electric power plant. In the coming autumn the Coindre Power Station will be supplying additional energy for the railway. The coefficient of working costs was reduced, and the financial situation of the electrified lines appears to be improving. Another interesting feature of the report is the reference to the part which the railway companies are taking in developing road transport services, particularly in districts where the traffic is too light to allow of local lines being worked at a profit. All the railway companies are preparing programmes for combined rail and road motor vehicle services, and as attempts to resuscitate moribund local lines with the aid of rail motors have not been uniformly successful, it is probable that such lines will, in time, be abandoned altogether in favour of road vehicles run by the railway companies. They seem to be in a fair way to obtain a monopoly of road transport within the territories covered by their system. The report of the Orleans Company states that this combination of rail and road transport is the "Working formula of the future."

Reconstruction.

The work of reconstructing the devastated regions is now practically terminated, and the association which was formed in 1915 to carry out that work immediately after the termination of hostilities has just been dissolved. The undertaking was a vast and complicated one, and could only be conducted successfully by a division of labour which necessitated the formation of other executive bodies, one of the most important being that which centralised the purchases of machinery and plant for the works and factories and collieries under reconstruction. The association was faced with the formidable task of preparing 5,000,000 acres of land for cultivation, reconstructing 56,000 kiloms. of road, 5200 kiloms. of railway, 1535 kiloms. of canals, 1200 bridges, 6000 metallic and other structures, 22,000 factories and workshops, and 290 coal pits. Incidentally, in addition to filling trenches and clearing up generally, the work involved the removal of 375,000,000 cubic metres of barbed wire. The factories have been reconstructed on the most modern and labour-saving lines, and their capacity is far greater than it was before the war.

Locomotive Cab Signals.

An accident outside the Gare du Nord in Paris, which resulted in the loss of at least fifteen lives and serious injuries to many other passengers, was caused by the driver of a train from Paris to Boulogne running through three stop signals, and entering into collision with a train approaching the station. The driver of the down train declared that he did not think that the stop signals were intended for him. It was only when the position of the signals showed that he was on an up line that he discovered his mistake, and then he did not dare to reverse for fear of causing an accident just outside the terminus where the traffic is particularly dense. This is not the first catastrophe of its kind, and it will hasten the carrying out of the programme for installing equipments on all the railways for the automatic repetition of signals in the locomotive cabs. For a long while past the railway companies have been fitting locomotives with automatic signalling devices and it was expected that, by now, the transformation would be completed. Whether the electric contacts can be always absolutely relied upon is another matter, but so far there has been no evidence of failure or lack of confidence in the efficiency of the system.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

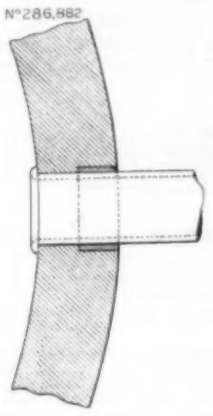
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

286,882. March 14th, 1927.—A CONNECTION FOR TUBES IN THICK TUBE PLATES, *A. Y. Imray*, 30, *Southampton-buildings, London, W.C.* 2.

This invention is concerned with the expanding of tubes into the comparatively thick tube plates of modern high-pressure water-tube boilers, which operation, it is urged, is difficult to

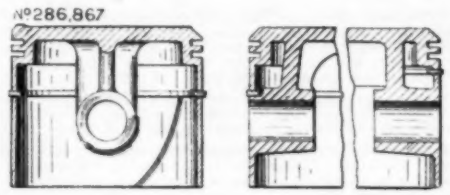


effect satisfactorily with ordinary expanding tools. As a consequence, the inventors propose to counterbore the tube hole, as shown in the drawing, and to expand and bead over the tube in the usual fashion. The space of the counterbore is then filled with a copper ferrule, which may be packed with asbestos or any other suitable material.—*March 15th*, 1928.

INTERNAL COMBUSTION ENGINES.

286,867. February 23rd, 1927.—PISTONS FOR FLUID PRESSURE ENGINES, E. Talbot, Zephyr Lodge, The Avenue, Lowestoft.

In certain types of internal combustion engines, there is, according to this specification, considerable difficulty in preventing an excessive amount of oil passing beyond the piston into the combustion chamber, and in practice it is found that this cannot be entirely prevented, either by increasing the number of packing rings or by causing the latter to exert a greater pressure upon the cylinder walls. It has also been found that the amount of oil which gets past the piston when the latter has a circumferential gap between the skirt and the ring-carrying portion is even greater than in the plain sided piston, but, as is

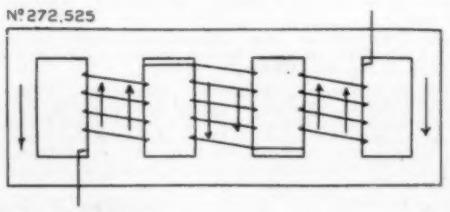


well known, it is highly desirable to provide this circumferential gap whether the piston is formed of one piece or the skirt and the ring-carrying portion are separately formed and connected together. The object of the invention is to reduce the above-mentioned waste of oil, whilst at the same time retaining the advantages which arise from the use of the circumferential gap between the skirt and the ring-carrying portion. A packing ring is therefore arranged in the gap between the adjacent edges of the skirt and of the ring-carrying portion, whether this gap is provided in a one-part piston or is formed in the manufacture of a piston having a separately formed skirt attached to the ring-bearing portion.—*March 15th*, 1928.

TRANSFORMERS AND CONVERTERS.

272,525. June 9th, 1927.—IMPROVEMENTS IN OR RELATING TO ELECTRIC TRANSFORMERS, International General Electric Company, of 120, Broadway, New York.

According to this invention, the height of a single-phase

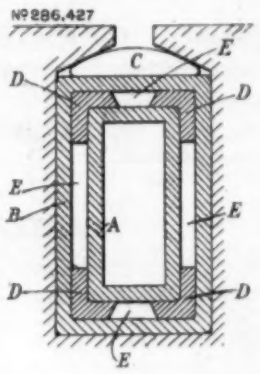


transformer is reduced by distributing the primary and secondary windings over three or more limbs, the windings on the individual limbs being so connected that the flux in all the adjacent limbs has an opposite direction, and so that the flux in all the limbs has the same density.—*March 8th*, 1928.

ELECTRICAL APPLIANCES.

286,427. February 3rd, 1927.—IMPROVEMENTS CONNECTED WITH THE WINDING OF ELECTRIC MACHINES AND APPARATUS, The English Electric Company, Ltd., of 28, Kingsway, London, W.C. 2, and Giulio Schroeder, of "Sandilands," Madeira-road, West Byfleet, Surrey.

According to this invention the slot insulation of electrical

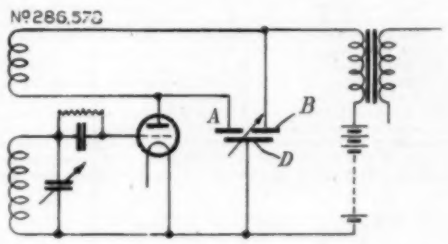


windings is composed of two tubes A and B, which are held in position by wooden wedges C. The tubes are separated from one another by four distance pieces D, so that passages E are formed for cooling fluid. The invention is particularly applicable to high-voltage induction regulators, immersed in oil.—*March 8th*, 1928.

TELEGRAPHS AND TELEPHONES.

286,578. November 15th, 1927.—IMPROVEMENTS IN OR RELATING TO THERMIONIC VALVE CIRCUIT SYSTEMS, Igranic Electric Company, Ltd., of 147, Queen Victoria-street, London, E.C. 4, and Harold Hopwood, 65, Victoria-road, Bedford.

The primary object of the invention is the provision of means whereby the high-frequency current in the reaction coil may be controlled without the tuning of the grid circuit being appreciably affected. Another object is the provision of means whereby the high-frequency current in the plate circuit may be kept to

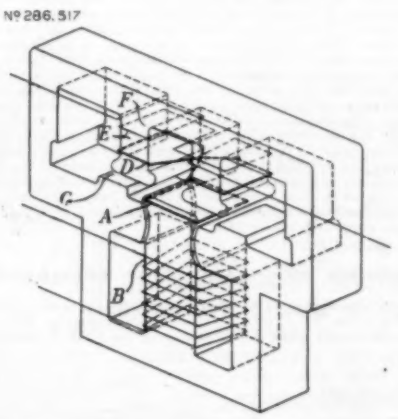


some extent from the low-frequency end thereof. The high-frequency current flowing in the reaction coil is controlled by means of a balancing condenser, the controlling operation of which does not vary the capacity from the high potential to the low potential side of the valve. The high-frequency valve has an input circuit comprising a grid coil and an output or plate circuit, comprising a reaction coil having a fixed coupling to the grid coil. The two ends of the reaction coil are respectively connected to two sets A and B of fixed vanes of a balancing condenser, and the filament of the valve is connected to the set D of movable vanes of the condenser.—*March 8th*, 1928.

MEASURING AND TESTING INSTRUMENTS.

286,517. May 19th, 1927.—IMPROVEMENTS IN ELECTRICITY METERS, *Metropolitan-Vickers Electrical Company, Ltd., of 4, Central-buildings, Westminster.*

This specification describes an arrangement for power factor compensation for electricity supply meters at all temperatures. A short-circuited conducting loop A embraces the shunt pole portion B at a position adjacent to the air gap C. The special feature is that the loop A co-operates with another short-circuited loop D on the series pole portions E. The loop D is in

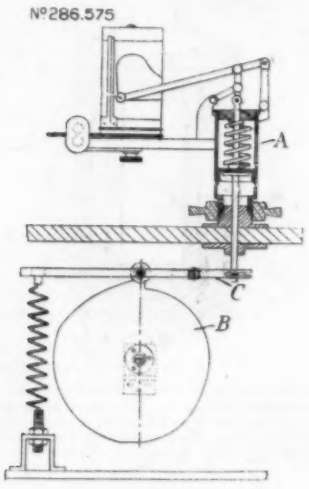


the form of the figure eight, and the ends surround the pole portion E in opposite directions in accordance with the direction of the flux flow in these poles as determined by the series coils F. The loop A is composed of brass and has a lower temperatur coefficient than the loop D, which may be composed of copper With the resistance values of the loops A and D adjusted to compensate the meter for power factor charges and with the differential temperature resistance charge properly balanced the actuating flux from the pole portions B and E will be maintained in substantially constant relation to the load for all

power factor and temperature conditions. In this instance the loop A over-compensates and the loop D under-compensates the meter, the temperature coefficients and resistances thereof being selected to nullify the effects of temperature changes and to maintain the adjustment for power factor changes substantially constant.—*March 8th*, 1928.

286,575. November 8th, 1927.—STEAM ENGINE INDICATORS, C. J. M. Flood, Technical Institute, Wimbledon, S.W. 19.

The idea of this apparatus is to familiarise students with the operation of the indicator. The indicator A is worked in con-

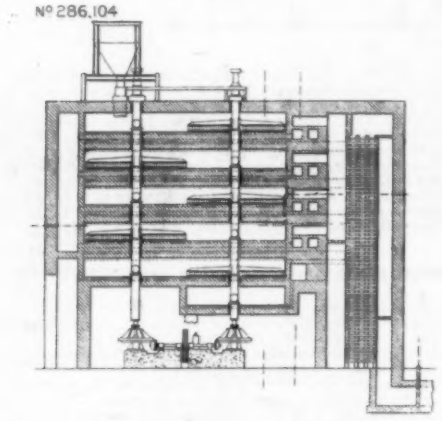


junction with a model engine, not shown in the drawing reproduced, and the movements of the indicator piston, which would be caused by the variations of the steam pressure, are produced by the cam B and link work C. The cam is appropriately shaped and is geared with the engine crank shaft.—*March 6th*, 1928.

GAS PRODUCERS.

286,104. August 23rd, 1926.—THE DISTILLATION OF COAL, H. M. Ridge, 2, Great Winchester-street, London, E.C. 2.

According to this invention, the volatile constituents of coal and similar materials are obtained by crushing the coal or other raw material, unless it is already small, preferably to a substantially uniform degree of fineness, causing the crushed material to traverse a succession of horizontal hearths—which may be provided with steps between the zones to facilitate the travel of the material—in a retort in a comparatively thin layer with continuous stirring or agitation of the material during its progress through the retort so as constantly to bring fresh particles of the material into contact with the hearths which are heated by means of gas-fired ducts underneath them, and thereby maintaining the thermal conductance of the layer of material in spite of the rapid rate of distillation of the volatile constituents. The rapid generation of hydrocarbons and their

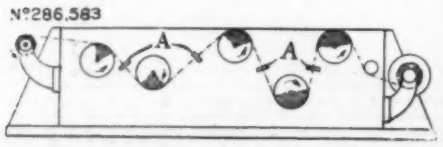


immediate withdrawal from the retort reduces cracking to a minimum. If desired, the withdrawal of the volatile hydrocarbons from the retort may be expedited by admitting an inert gas or gases or steam or spraying small quantities of water into some or all of the hearths to form steam, so as to displace the gases more rapidly. By leading off the gases from the several hearths of the retort separately and condensing them in separate condensers, the oils obtained from the coal or the like can be graded to a considerable extent in the distillation process, thereby reducing the expense and time otherwise required for grading the products by fractionation. Such grading during distillation may be furthered by working the several hearths in one retort at different temperatures. In the case of the distillation of coal or lignite the solid coke residue containing some pitch and tar may be briquetted while still hot, and a lump product obtained which gives reasonably smokeless combustion in an open grate.—*February 23rd*, 1928.

MACHINE TOOLS AND SHOP APPLIANCES.

286,583. December 14th, 1927.—CONTINUOUS WIRE-DRAWING MACHINES, *H. A. Gill*, 51, *Chancery-lane, London, W.C.* 2.

The inventors point out that one of the chief difficulties in



drawing fine wires at high speeds is the breakage of the wire, caused by its being bent round the drawing rolls through angles greater than 180 deg. As a consequence they do not wrap the wire round the rolls, as is usual, but merely lead it over them as shown in the cut. The rolls can be adjusted as to position in the frame and are so placed that, as the wire is drawn finer, the angle of contact with the rolls is reduced. The wire is drawn from right to left and the dies are shown at A A. It is claimed that in this way nickel wire 0·1 mm. in diameter can be drawn without trouble.—*March 8th*, 1928.

MOTOR CARS AND ROAD TRAFFIC.

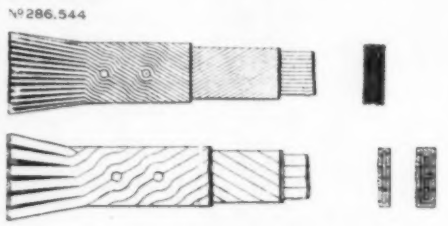
284,332. January 25th, 1928.—IMPROVEMENTS IN OR RELATING TO TRACKLESS ELECTRIC VEHICLES, *Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.*

It is proposed to provide electric battery vehicles with rectifiers so that the batteries can be charged from alternating-current mains. It is pointed out that the reason this has not been done before is that most of the rectifying devices available were unsuitable for the purpose, but in accordance with this invention it is proposed to employ the modern copper oxide rectifier, which is very durable and is not affected by shocks. Moreover, it occupies little space and costs nothing to maintain. The scheme is said to be most suitable for electric trucks, although it may be applied to all types of battery vehicles.—*March 15th*, 1928.

MISCELLANEOUS.

286,544. July 22nd, 1927.—SCREENS FOR CLASSIFYING COAL, &c., S. Hunter, Newlyn, Penzance.

In the place of the strips of hickory wood usually employed to support jigging screens the inventor proposes the use of wire ropes to minimise troubles through breakage. He stipulates



that the rope should be flat and broad as shown in the cross sections, and suggests that the ropes may be fastened by bolts through holes near the ends, while the ends should be splayed out and filled with white metal. It is stated that such ropes have a flexibility very similar to that of hickory strips and a much longer life.—*March 8th*, 1928.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

CHEMICAL ENGINEERING GROUP.—Visit and joint meeting with the Birmingham Section, Engineers' Club, Waterloo-street, Birmingham. "The Heat Treatment of Ferrous Metals," by Dr. C. M. Walter. 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. "An Outline of the Distribution of Petroleum," by Mr. W. M. Hurrell. Discussion and re-exhibition of slides. 7.30 p.m.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, London. General meeting. "The Causes of Failure of Wrought Iron Chain and Cable," by Messrs. H. J. Gough and A. J. Murphy, and "The Third Report of the Wire Ropes Research Committee." 6 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Bolbec Hall, Newcastle-upon-Tyne. "W/T Direction Finding for Marine Purposes," by Dr. S. H. Long. 6 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "Heirlooms of Industry in the Science Museum," by Colonel Sir Henry G. Lyons. 9 p.m.

TO-DAY AND SATURDAY, APRIL 21ST.

MODEL RAILWAY CLUB.—Kingsway Hall, London W.C. 2. Sixth annual exhibition. 11 a.m. to 10 p.m. daily.

TO-DAY AND TILL THURSDAY, APRIL 26TH.

BUILDING TRADES EXHIBITION AT OLYMPIA.

SATURDAY, APRIL 21ST.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Lecture Theatre of the Institute, Newcastle-upon-Tyne. The following papers will be open for further discussion :—"Electric Mine Lamps and Better Lighting," by Mr. William Maurice; "A New Gas Detecting Miners' Electric Lamp," by Professor W. M. Thornton; "Notes on High Candle-power Lamps," by Mr. H. Staples. The following papers will be read :—"Some Notes on Quarrying by the Well Drill Method," by Dr. William Cullen; "A Few Notes on an Explosion of Gunpowder," by Mr. R. J. Weeks. 2.30 p.m.

MONDAY, APRIL 23RD.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Meeting of the Scottish Centre at the Royal Technical College, Glasgow. "Some Notes on Crank Shafts," by Major F. Strickland. 7.30 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. Dr. Mann Lecture, "Applied Architectural Acoustics," by Mr. A. G. Huntley—Lecture II. 8 p.m.

THE INSTITUTION OF ELECTRICAL ENGINEERS: NORTH-EASTERN CENTRE.—The annual general meeting will be held in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne. Following the ordinary business a paper will be read by Mr. F. Lydall on "The Electrification of the Pietermaritzburg-Glencoe Section of the South African Railways." 7 p.m.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, S.W. 1. Graduates' Section, London. "Pulverised Coal Systems," by Mr. H. Heywood. 6.30 p.m.

TUESDAY, APRIL 24TH.

THE ILLUMINATING ENGINEERING SOCIETY.—At the Home Office Industrial Museum, Horseferry-road, Westminster, London, S.W. Discussion on "Daylight, Artificial Light, Artificial Daylight: Their Merits and Drawbacks," will be opened by Mr. J. S. Dow. 6 p.m.

THE INSTITUTION OF CIVIL ENGINEERS.—Great George-street, Westminster, S.W. 1. Ordinary meeting. Paper to be further discussed, "Deep-water Jetty at Bevan's Cement Works, Northfleet," by Messrs. Charles Percy Taylor and Oscar Faber. 6 p.m.

WEDNESDAY, APRIL 25TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Joint meeting of the Birmingham Centre, the Graduates' Branch and the Birmingham Branch of the Institution of the Rubber Industry at the Midland Institute. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Meeting of the North of England Centre at the Engineers' Club, Albert-square, Manchester. Informal talk on "Magneto Design and Development," by Mr. E. A. Watson. 7 p.m.

NEWCOMEN SOCIETY.—Prince Henry's Room, 17, Fleet-street, E.C. 4. "Steamers of Lake Champlain, 1809 to Present Day," by Mr. L. F. Loree. 5.30 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. "The Education and Training of the Blind," by Dr. J. M. Ritchie. 8 p.m.

THE INSTITUTION OF CIVIL ENGINEERS.—Great George-street, Westminster, S.W. 1. Annual general meeting of the Association of London Students. 6.30 p.m.

THURSDAY, APRIL 26TH.

JUNIOR INSTITUTION OF ENGINEERS.—Monico Restaurant, Piccadilly-circus, W. 1. Annual dinner. 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. "Flying Boats," by Herr C. Dornier. 6.30 p.m.

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—In the Hotel Metropole, Leeds. "Railway Construction in the Pyrenees," by Mr. C. J. Chaplin.

FRIDAY, APRIL 27TH.

INSTITUTION OF ENGINEERS-IN-CHARGE.—Venetian Chamber, Holborn Restaurant, London. Annual dinner. 6 p.m. for 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Informal meeting. "The Manufacture of Structural Steel," by Mr. C. Hulbert Plant. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "Carriers of Electricity in the Atmosphere," by Dr. Arthur M. Tyndall. 9 p.m.

THE INSTITUTION OF ELECTRICAL ENGINEERS.: NORTH-EASTERN CENTRE.—Visit to the Singapore Floating Dock at Messrs. Swan, Hunter and Wigham Richardson's Yard, Wallsend (Station-road entrance), at 4.45 p.m. After the inspection of the dock. Mr. E. T. Williams, M.I.E.E., Assistant Director of Electrical Engineering at the Admiralty, will deliver a lecture on "The Electrical Equipment of the Dock," which will be followed by a discussion. 7.30 p.m.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, S.W. 1. Informal meeting. "Pulverised Fuel in Locomotive Furnaces," introduced by Mr. J. Clubley Armstrong. 7 p.m.

SATURDAY, APRIL 28TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Visit of the London Graduates to the Croydon Aerodrome. Assemble at the Aerodrome gates at 2.30 p.m.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—West Midland District meeting at Stafford.

MONDAY, APRIL 30TH.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. Dr. Mann Lecture, "Applied Architectural Acoustics," Lecture III., by Mr. A. G. Huntley. 8 p.m.

TUESDAY, MAY 1ST.

DIESEL ENGINE USERS ASSOCIATION.—19, Cadogan-gardens, London, S.W. 3. "Some Considerations regarding the Peak Load Problem and High-powered Peak Load Diesel Engines," by Mr. M. Gercke.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Meeting of the Luton Graduates at the Royal Hotel, Mill-street, Luton. "Modern Methods of Engineering Inspection," by Mr. G. D. Ricketts. 7.30 p.m.

WEDNESDAY, MAY 2ND.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Wireless Section meeting. An informal discussion will take place on "Screened Grid Valves." The subject will be introduced by Mr. M. G. Scroggie. 6 p.m.

THURSDAY, MAY 3RD.

IRON AND STEEL INSTITUTE.—Connaught Rooms, Great Queen-street, London, W.C. 2. Annual dinner. 7 for 7.30 p.m.

THURSDAY AND FRIDAY, MAY 3RD AND 4TH.

IRON AND STEEL INSTITUTE.—At the house of the Institution of Civil Engineers, Great George-street, London, S.W. 1. Annual meeting. For Programme see page 375.

FRIDAY, MAY 4TH.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "Credit and Currency," by the Right Hon. Reginald McKenna. 9 p.m.

TUESDAY, MAY 8TH.

THE INSTITUTE OF METALS.—The Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. Eighteenth annual May lecture, "The Chemical Properties of Crystals," by Professor Cecil H. Desch. 8 p.m.

THURSDAY, MAY 10TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Meeting of the Derby Graduates at the Cavendish Café, Cornmarket, Derby. "Free Wheel Devices," by Mr. C. Mercy. 7.30 p.m.

ROYAL AERONAUTICAL SOCIETY.—At the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. "Design and Construction of Modern Rigid Airships," by Mr. B. N. Wallis. 6.30 p.m.

WEDNESDAY, MAY 16TH.

OVERHEAD LINES ASSOCIATION.—At Institution of Electrical Engineers. Mr. D. C. Redfern, Engineer, Lothians Electric Power Company, will open a discussion on "Standard Overhead Lines: Their Advantages and Number of Different Standards Required." 5.30 p.m.

ROYAL METAL TRADES PENSION AND BENEVOLENT SOCIETY.—Second annual golf competition at Sundridge Park Golf Club, Bromley, Kent.